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Climate-Smart Agriculture Prioritization Framework (CSA-PF) Report for Guyana

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Climate-Smart Agriculture Prioritization Framework (CSA-PF) Report for Guyana

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Acronyms

AEZ	Agro-ecological zone
AGB	Above-ground biomass
BAU	Business as usual
CBA	Cost-benefit analysis
C/B	Cost-benefit ratio
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CIAT	International Center for Tropical Agriculture
CSA	Climate-smart agriculture
CSA-PF	Climate-Smart Agriculture Prioritization Framework
DR	Discount rate
EPA	Environmental Protection Agency
FFS	Farmer field schools
FGD	Focus group discussion
GHG	Greenhouse gas
GRDB	Guyana Rice Development Board
GYD	Guyanese dollar
IPM	Integrated pest and disease management
IRR	Internal rate of return
NAREI	National Agricultural Research & Extension Institute
NDIA	National Drainage and Irrigation Authority
NGMC	New Guyana Marketing Corporation
NPV	Net present value
O&M	Operation & maintenance
PP	Payback period
VC	Value chain

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Introduction

In Guyana, there are ongoing efforts to build climate change resilience from local to national level. The heterogeneous production systems increase the complexities in planning, highlighting the need to strengthen cooperation between different stakeholders and institutions to build a more climate change-resilient food system.

Climate-smart agriculture (CSA), which incorporates **adaptation/resilience and mitigation measures while ensuring sustainable productivity**, has the potential to build synergies and limit tradeoffs in agriculture under present climate uncertainties, and reduce existing knowledge gaps and facilitate alignment between sectors and policies. Despite the involvement of several organizations across Guyana in implementing programmes intended to improve climate change resilience, the abilities of communities to cope with the barriers and opportunities that come along with climatic variability are still not well understood and, therefore, require higher priority to achieve CSA goals.

Effective and long-lasting management and adoption of the different climate change adaptation strategies also remain highly complicated because of localized and context-specific responses, which vary from region to region. Developing farmers' capacities and knowledge to make climate-smart choices in their agricultural production systems is crucial and requires in-depth understanding of the local socio-economic contexts and the suitability of practices in different agro-ecologies.

Local institutions also often have limited access to information on climate change, its potential impacts on agriculture and possible climate-smart strategies to address these impacts. Without targeted interventions, Guyana will continue to respond to climate change-related threats and opportunities in an ineffective manner that will ultimately negatively impact on Guyana's farming communities. It is important for the national government, with the support of other experts on CSA, to collaborate to strengthen national and local capacities and knowledge to deal with the effects of climate change.

Climate-Smart Agriculture Prioritization Framework Objectives

The CSA-PF seeks to develop a framework for prioritization of crops and CSA investments in sustainable agricultural interventions in Guyana.

1

Co-implement a framework that provides a systematic process for targeting investment towards best-bet CSA options to boost the sustainability of the Guyanese food system in the face of climate change.

2

Identify existing and promising CSA practices and assess the trade-offs and synergies between practices using CSA-related indicators, the costs and benefits of adopting the practices and their possible opportunities and barriers to adoption.

3

Contribute to optimized sub-national and national planning, promoting a participatory process for the development of potential CSA investment portfolios adapted to the context of small-scale farmers.

CSA-PF methodology overview

The CCAFS-CIAT CSA Prioritization Framework (CSA-PF) is a participatory and multi-criteria decision-making process, co-designed as a holistic tool to support information-based CSA investments. CSA-PF has the objective to help decision-makers identify best-bet CSA investment portfolios that achieve gains in national food and nutrition security, farmers' resilience and adaptation capacity to climate change, and, where possible, reduce greenhouse gas (GHG) emissions in the food system. The framework is divided into four additive phases: *1) Initial assessment of CSA options; 2) Identification of top CSA options; 3) Calculation of costs and benefits of top CSA options; and 4) Evaluation of opportunities and barriers to adoption of CSA options, to finally co-create the CSA investment portfolio(s).* The CSA investment portfolios are context-specific selection of priority agricultural practices and technologies that seek to maximize investment yield, explore possible synergies and avoid trade-offs, minimize income risk, and address priorities of various agricultural stakeholders harmonizing socio-cultural, political-institutional, environmental, economic, and educational considerations in the territory.

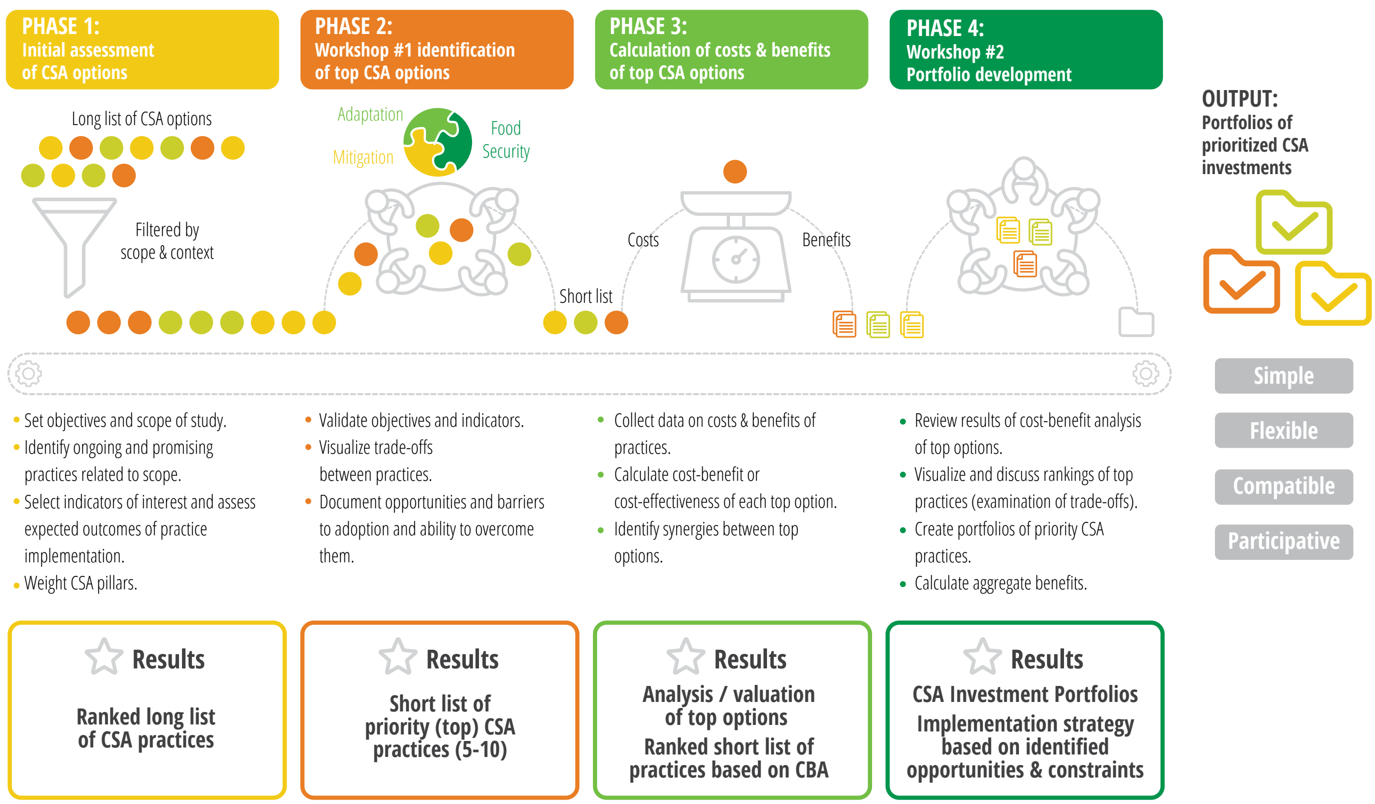


Figure 1 CSA-Prioritization Framework methodology overview

The CSA-PF methodology and previous experiences in various countries can be further explored in the CSA guide website as well as the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) web repository.

CSA-PF process in Guyana

The Prioritization process started with the analysis and results presented in the 1st Progress narrative report in January 2019. This document addressed the key elements to build up the context of the prioritization process (Phase 1) and was the result of a collaborative effort of the project steering committee[1]. The committee was represented by the Permanent Secretary (Ministry of Agriculture), the Project Coordinator (National Agricultural Research & Extension Institute-NAREI), the Guyana Rice Development Board (GRDB), Guyana Sugar Corporation, the Office of Climate Change (OCC) of the Ministry of the Presidency, the University of Guyana (UG), the Faculty of Earth and Environmental Sciences (UG), and CIAT along with other stakeholders.

The Climate-Smart Agriculture Prioritization Framework methodology (Figure 1) and the CSA concept were introduced to the participants in each phase in order to contextualize the activities of each meeting and provide a clear understanding of the theory, definitions, and the process entailed by this component of the project. The stakeholder engagement process in each phase involved one or several techniques and strategies to shape the process and collect the necessary information for subsequent quantitative and qualitative analyses. The type of actors connected with the process comprised farmers, academia and research organizations, private sector, government institutions, cooperation, and NGOs, among others.

As shown in Figure 1, the moments in which these actors interacted to exchange ideas included:

1 **Kick-off meeting** with the steering committee with more than 5 national institutions to set up the initial approach, objectives and scope of the development of the methodology including the working regions, initial mapping of potential agricultural production systems and CSA practices among other details of phase 1.

3 **Workshops** that brought together 73 representatives from a wide range of stakeholders. The first workshop took place in Georgetown during phase 1, in order to evaluate and identify the top 10 CSA practices suitable for the context of the analysis. The second and third workshops in phase 4 were conducted in Regions 3 and 9, respectively, with the purpose of collectively designing the investment portfolios based on the inputs from all previous phases.

2 **Focus group discussions (FGD)** with more than 18 experts among farmers and staff from NAREI, GRBD, among other institutions, to gather information on 20 prioritized CSA practices to inform the economic analysis during phase 3, whose purpose is to quantify the economic costs and benefits of the measures.

***** Permanent **review of literature and specialized agricultural databases**, coupled with **consultation with experts,** was conducted to fill gaps and complement key information during the process.

[1] The steering committee was represented by the Permanent Secretary (Ministry of Agriculture), the Project Coordinator (National Agricultural Research & Extension Institute-NAREI), the Guyana Rice Development Board–GRDB, Guyana Sugar Corporation, the Office of Climate Change (OCC) of the Ministry of the Presidency, the University of Guyana (UG), the Faculty of Earth and Environmental Sciences (UG), experts from the agricultural sector, and CIAT along with other stakeholders.

Results and analysis of the process through the prioritization phases

Phase 1 and 2. Scope of the assessment: production systems, regions, and CSA practices identification and assessment

Agro-ecological zones

Two pilot regions of interest, Region 3 in the coastal area (Essequibo Islands-West Demerara) and Region 9 in the hinterland (Upper Takutu-Upper Essequibo) were selected during the preceding workshop with the steering committee (CIAT, 2019).

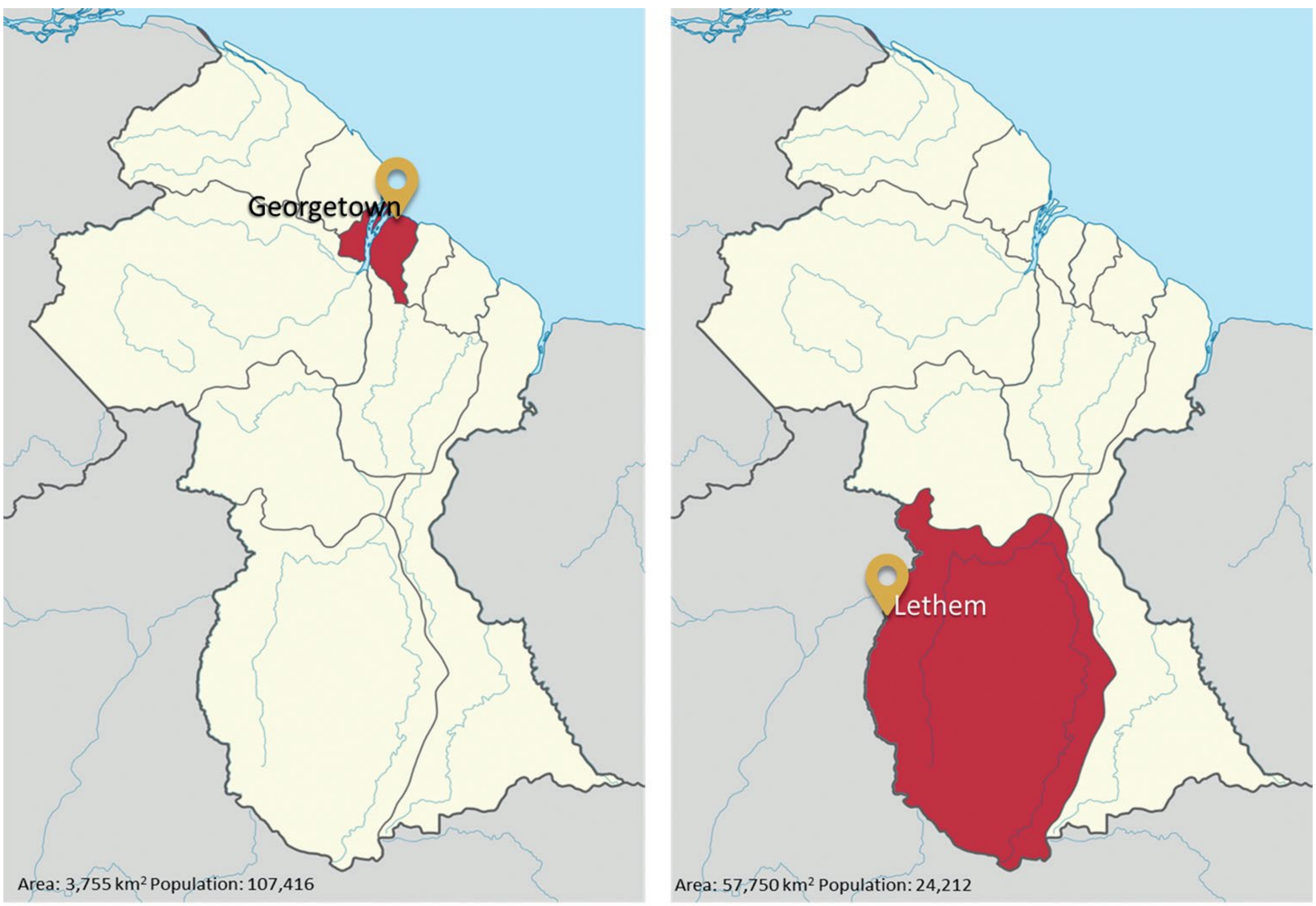


Figure 2. Selected regions and workshop sites: Essequibo Islands-West Demerara, and Upper Takutu-Upper Essequibo, Guyana.

Production Systems (Crops)

A preliminary selection of relevant production systems that was discussed and validated by the steering committee and country stakeholders during the first workshop considering the nutritional, economic and productive relevance of each crop[2] in the regions of focus. The target farmers in the process are mainly small-scale female and male farmers (and vulnerable groups).

The participants of the first workshop comprised representatives of various actors in the agricultural sector including farmers from both regions. During the working session, participants discussed major production systems – root crops, fruits, cereals or nuts – relevant to each regional context and additionally identified two zones/areas within the region with contrasting agroecological, agronomic, or socio-cultural characteristics, in order to identify potential CSA options (see Table 1 and Annex 1).

From the preliminary list including crops such as rice, plantain, cassava, sweet potato, coconut, and pineapple, participants agreed to perform the subsequent analyses for rice, plantain, cassava, sweet potato, coconuts, and pineapples for Region 3, and rice, plantain, cassava, and sweet potato in addition to cashew nuts and peanuts for Region 9.

Climate risks

For each region and zone, participants indicated the two main climatic risks impacting their production systems. To that end, participants were provided with a summary table collated and ranked according to historical frequency and severity of impact. This information was extracted from preliminary regional risk and vulnerability assessments conducted by the Guyana Civil Defence Commission (CDC) in 2016 and 2017, for Regions 3 and 9, respectively (Drakes, 2016; Drakes and Benn, 2017). As presented in Table 1, the results suggested that drought and flooding, including erosion and wild fire events, as well as incidence of pests and diseases, are the most common and significant risks (Figure 3).

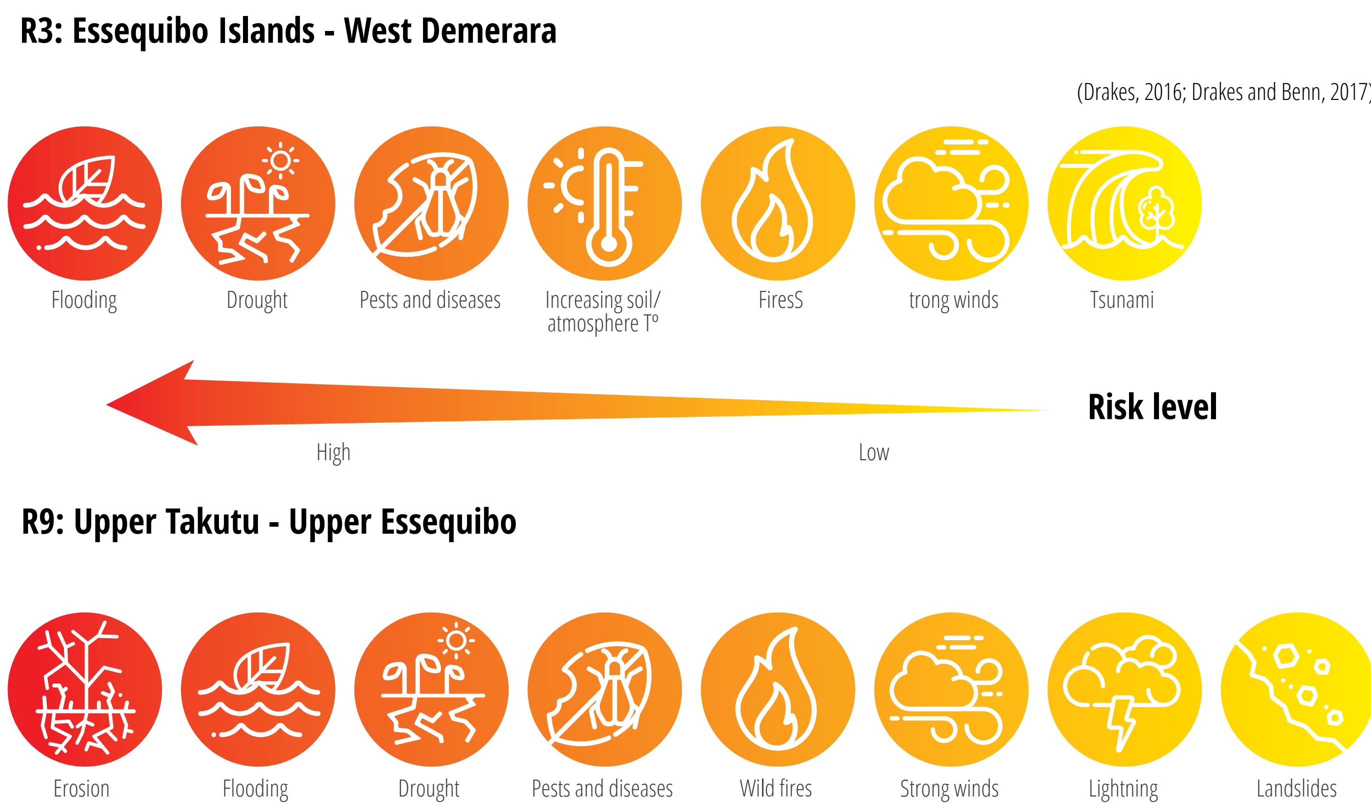


Figure 3. Climate-related risks in Regions 3 and 9 in Guyana.

[2] A preliminary database review was carried out to gather specific data of each parameter to create the list of potential production systems (crops). The process is presented in detail in the 1st progress narrative report (CIAT, 2019).

The following table compiles the different hazards and differentiating characteristics of identified areas (A and B) for the prioritized crops within each region.

Table 1. Regions, zones, production systems and risks associated with climate change.

Region	Production System	Zone			Risks		
		Zone name		Differentiating characteristics	Main 1	Main 2	Associated
3	Cassava	A	Parika	Soils with high clay content; similar weather conditions compared to zone B	Drought	-	
		B	Canal 1 & 2	Pagasse soils with higher acidity; similar weather conditions compared to zone A	Flooding	-	
	Coconut	A	Essequibo islands; Leguan; Wakenaam	Clay soils; Wakeenaam and Hog islands	Flooding	Pests and diseases	
		B	Salem Back-dam; Hoac	Pagasse soils	Flooding	Pests and diseases	
	Pineapple	A	Parika	Pagasse soils	Flooding	Pests and diseases	
		B	Canal #1 and Boeraserie conservancy	Pagasse and Sandy clay soils	Flooding	Pests and diseases	
	Plantain	A	Parika	Clay soils; high rainfall; less acid soils	Drought	Pests and diseases	
		B	Canal 1 & 2	Paggase and clay soils; lower rainfall; soils with low pH	Flooding	Pests and diseases	
	Rice	A	Leguan Island	Limited or not existent irrigation facilities (saline conditions); sodic soil type	Drought	Pests and diseases	
		B	Crane, West Coast Damerara	Fresh water supply through conservancies; Clay and Pagasse soil (an organic soil also known as tropical peat and of similar composition to the commonly known peat).	Flooding	Pests and diseases	
	Sweet potato	A	Parika	Clay soils	Drought	-	
		B	Canal 1 & 2	Pagasse and clay soils; soils with lower pH	Flooding	-	
9	Cassava	A	Central and North Rupununi	Wetlands landscape; loamy clay soil.	Drought	Flooding	-
		B	South-Central & Deep-South Rupununi	Savanna landscape; mountainous; sandy loam soil.	Drought	Flooding	-
	Cashew nut	A	Central Lethem	Sandy soil (black), porous/light soil; one rainfall season (prone to flooding); drought and extreme temperatures that make the zone prone to wild fires; no major problems with market access.	Wild fire	Drought	Pests and diseases
		B	Deep South	Red loam/mud; one rainfall season (prone to flooding); drought and extreme temperatures that make the zone prone to wild fires; no major problems with market access.	Wild fire	Flooding	

9	Peanuts	A	Central Lethem	Sandy soil (black), porous/light soil; one rainfall season (prone to flooding); drought and extreme temperatures that make the zone prone to wild fires; no major problems with market access.	Wild fire	Drought	Pests and diseases
		B	Deep South	Red loam/mud; one rainfall season (prone to flooding); drought and extreme temperatures that make the zone prone to wild fires; no major problems with market access.	Wild fire	Flooding	
	Plantains	A	Karasabai	Approximated area 10-15 Acres under cultivation; semi-forested areas; mountainous-highlands; low soil fertility; deep soil; lower water holding capacity; more frequent fires; more affected by drought; pests and diseases e.g. Yellow sigatoka.	Drought	-	Pests and diseases
		B	Sand Creek	Approximated area 30 Acres under cultivation; semi-forested areas; flatter than - lowlands; low soil fertility; shallow soil; higher water retention capacity; prone to floods and wild fires.	-	Flooding	Wild fire
	Rice	A	Aishalton	Highland savannas; less access to water for irrigation; low fertility soils; low soil water holding capacity; areas with pH <4.5; dominant type of vegetation is shrub; rice is planted in flat areas (average area 6 ha).	Drought	-	Wild fire
		B	Santa Fe	Access to river; flood prone; greater soil water holding capacity compared to Zone A; low soil fertility; flat wetland areas relatively higher (average area 300 ha).	-	Flooding	Wild fire

CSA practices

A draft long list of current and potential CSA practices and technologies was prepared based on an extensive local and regional literature review (see Annex 2). This list was aligned with the portfolios' objectives, meaning that it is a comprehensive set of CSA options that covers environmental/climatic hazards for both regions. It also considered the Value Chain perspective (i. Input supply; ii. on-farm production; iii. post-harvest, processing and storage; iv. transport and marketing) looking to be gender sensitive, farmer-scale appropriated, and encouraged agricultural diversification.

After analyzing and discussing 6 to 14 CSA practices and technologies per production system, most of the options highlighted by participants were focused, but not limited to "on-farm" stage, indicating the importance of promoting options that are directly available for and implementable by producers at the farm level. However, some practices require institutional support as discussed below.

Identifying best-bet solutions for complex problems and contexts requires several layers of screening to contextualise and scale up the implementation of CSA practices (Neufeldt et al., 2015). Therefore, multiple criteria assessment allows stakeholders to invest their attention, time, and energy focusing on the most suitable options for their agroecological context, which will lead to more informed decisions. In this sense, once participants have a clear idea of potential CSA practices suitable for the regions, zones, crops, and specific climatic risks, then they proceed to reduce the number of options to at least eight based on a multidimensional assessment through five guiding questions:

- **Socio-cultural:** Is the CSA practice known and accepted by stakeholders – mainly farmers – and/or is present in local community activities and projects?
- **Environmental:** Does the CSA practice preserve and/or make efficient use of natural resources such as water, soil and biodiversity?
- **Economic:** Are the input materials and/or implementation/maintenance costs of the CSA practice accessible and/or affordable by farmers?
- **Political/institutional:** Does the CSA practice promote local governance and/or is in line with current government plans and policies, and/or projects of agricultural related institutions?
- **Educational/information:** Can the CSA practice be adopted in the short- to medium-term because there exists technological and/or human capacities to implement it?

After agreeing on the pertinence of the questions, selected CSA practices from the long list were evaluated in working groups, using a qualitative rating scale[3], the results (presented in table below) were then used to identify the Top 4 CSA options by region and production system in order to move forward with the prioritisation process.

Table 2. Multidimensional assessment of CSA practices by region.

Region	Production System	CSA practices	V.C. stage	Contextual dimensions					AVER.
				S-C	ENV	ECN	P-I	E-I	
3	Cassava	Improved drainage systems	ii	10	10	2	10	7	7.8
		Water efficient irrigation	ii	10	10	2	10	7	7.8
		Use of climate-resilient varieties	i	7	9	7	7	6	7.2
		Community seed bank (planting material)	i	7	7	7	4	8	6.6
		Crop rotation	ii	0	7	10	10	4	6.2
		Agroforestry systems	ii	0	5	8	1	2	3.2
	Coconut	Diversification of coconut varieties (flood)	ii	8	10	10	10	8	9.2
		IPM (biological control, trap crops)	ii	5	5	8	10	9	7.4
		Improved land drainage systems	ii	5	8	5	10	7	7
		Use of climate-resilient varieties	i	0	8	10	10	4	6.4
		Agroforestry systems	ii	2	4	5	10	3	4.8
		Diversification of coconut varieties (pests and diseases)	ii	8	10	10	10	8	9.2
	Pineapple	IPM: Intercropping plantain and/or Sorrel	ii	8	8	10	10	10	9.2
		Plant nurseries	i	5	8	10	10	9	8.4
		Climate-resilient varieties (e.g. Monserrat)	i	7	9	10	10	5	8.2
		Water management reservoirs/ponds and irrigation + pumps	ii	5	8	8	8	6	7
		Planting material storing	iii	5	6	10	4	9	6.8
		Agroforestry systems	ii	3	7	7	10	2	5.8
	Plantain	Improved land drainage (excavation/drains)	ii	8	9	9	9	9	8.8
		Improved irrigation systems (e.g. sprinkler)	ii	7	8	9	9	9	8.4
		Mulching/Cover crops	ii	7	7	6	8	8	7.2
		Planting time based on crop calendars	ii	2	7	7	8	5	5.8
		Use of climate-resilient varieties - tolerant to flood	i	2	9	3	4	6	4.8
		Use of climate-resilient varieties - resistant to drought	i	2	9	3	4	6	4.8
	Rice	IPM (Biological control, monitoring)	ii	10	10	9	9	7	9
		Use of disease resistance varieties e.g. Blast	i	9	10	10	8	7	8.8
		Production and use of clean seeds	i	10	8	7	10	8	8.6
		Use of climate-resilient varieties	i	6	9	10	7	6	7.6
		Use of crop residues/straw incorporation after harvesting	i	8	8	10	5	3	6.8
		Alternate Wetting and Drying (AWD)	ii	3	9	8	5	2	5.4
	Sweet potato	Use of climate-resilient varieties resistant to flood	i	4	9	7	9	9	7.6
		Water efficient irrigation systems	ii	7	8	9	6	6	7.2
		Improved drainage systems	ii	2	9	7	9	8	7
		Use of rain water reservoirs	ii	8	8	8	8	3	7
		Use of climate-resilient varieties (drought)	i	2	7	8	6	7	6
		Use of shade houses	ii	3	9	3	6	6	5.4

[3] Qualitative scale ranged from 0 to 10, where 0 = The practice does not comply at all with the premises of the question; and 10 = The practice fulfills the premises of the question.

	Cassava	Crop Rotation with beans/pumpkin/watermelon	ii	10	10	10	10	10	10
		Improved land drainage systems	ii	9	9	6	10	9	8.6
		Small-scale equipment for cassava flour processing	iii	10	9	6	9	9	8.6
		Planting dates based on crop modeling	i	7	7	7	9	9	7.8
		Use of climate-resilient varieties (flood and drought)	i	6	8	3	10	9	7.2
		Water efficient irrigation systems (localized)	ii	6	8	3	9	7	6.6
		Community seed banks	i	3	7	4	8	9	6.2
	Cashew nut	Pruning	ii	9	9	9	5	8	8
		IPM: Field sanitation	ii	9	9	9	5	5	7.4
		Education and Capacity building*	-	7	8	5	8	8	7.2
		Water harvesting (specially for young plants)	ii	4	5	6	8	6	5.8
		Use of climate-resilient varieties	ii	0	0	0	0	0	ND
	Peanuts	IPM: Keep areas of natural habitat	ii	8	8	9	4	8	7.4
		Crop Rotation (e.g. with red beans)	ii	7	7	10	5	5	6.8
		IPM: Biological control (Neem)	ii	5	6	6	8	8	6.6
		Coordinated planting schedule	i	6	5	3	8	5	5.4
9		Improved drainage systems	ii	2	2	1	5	3	2.6
		Production and use of organic fertilizers	ii	3	1	3	1	1	1.8
	Plantain	Intercropping with cassava/pumpkin/watermelon	ii	8	8	9	9	9	8.6
		Field sanitation (infected residues management)	ii	7	8	8	8	9	8
		Support suckers for plants	ii	7	8	8	8	8	7.8
		Improved drainage systems	ii	4	7	8	8	9	7.2
		Crop rotation with legumes	ii	1	1	9	9	9	5.8
		Composting crop/farm residues	ii	1	1	8	5	5	4
	Rice	Time of planting	ii	9	9	8	8	9	8.6
		Land preparation for water conservation (incorporate crop residues and leveling)	ii	8	8	6	8	9	7.8
		Adequate fertilization (timing, source, amount and placement)	ii	3	7	7	8	9	6.8
		Improved drainage system	ii	5	7	8	6	6	6.4
		Adjusted seed density/rate (100-120 lbs/acre)	ii	3	2	8	8	9	6
		IPM - Seed treatment to prevent pests	ii	3	2	6	8	9	5.6
		Crop residues/straw incorporated after harvesting	ii	1	1	5	8	9	4.8
		Integrated pest management	ii	1	1	7	6	6	4.2

*Although *education and capacity building*, was proposed as a key practice by cashew nut working table, it was agreed to analyze it as an Off-farm/programmatic practice. This means that should not be assessed in the same way as the other practices. However it should be considered an essential strategy that generates the enabling environment for any CSA practice adoption and scale out.

It is important to highlight that the type of measures identified can be analyzed from different points of view, grouping them into different typologies or categories of agronomic management depending on the resource or need they address. Following the value chain approach, up to this point, 73% of the practices point to on-farm production stage (ii), followed by *input supply* (i) with 24%, and only 3% related to *post-harvest, processing and storage* (iii), without having measures directly related to *Transport and Marketing* stage.

The most relevant practices at the input supply stage were related to provision of seeds of varieties with some type of climate adaptation trait such as tolerance to drought or flood/logging conditions, and pest- and disease-tolerant varieties, e.g. for rust in rice. As for on-farm production, the trending practices target water management through the implementation of water efficient irrigation systems (e.g. drip and or micro-sprinklers), rain water harvesting systems/structures, and improved drainage systems. On the other hand, Pest and Disease Management (IPM) is also recognized in several crops as a relevant strategy to cope with climate change-related risks. Finally, viable CSA options in stage iii comprise small-scale equipment for cassava flour processing and planting material storing facilities. Community seedbanks were also a key programmatic practice that can apply – depending on the context – for both stage i and iii.

CSA practices smartness assessment

CSA indicators: In order to determine the level of climate smartness of the practices to reveal potential benefits on CSA pillars: Productivity/food and nutrition security, adaptation/resilience capacity and mitigation/low-emissions development. A suggested list of 15 indicators crosscutting to the CSA pillars[4] was reviewed by workshop participants, thus clarifying technical and methodological doubts and being able to propose new indicators. Subsequently, participants grouped in working tables were asked to select 10 relevant indicators for their context, initiating at the production system level on individual working tables, then considering the regional perspective between tables, and finally discussing in a plenary session the indicators with greater representativeness for both regions. The number of coincidences and capacity to tackle key CSA issues/elements from farm to regional levels were the common thread for agreeing on the final selection, which captures the needs and perspectives expressed by farmers, experts, and other key stakeholders. The final list of indicators is presented in Table 3.

Table 3. CSA indicators and guidance questions for practices assessment.

Productivity/food and nutrition security

1. **YIELD (YLD):** By implementing the CSA practice, what are the expected changes in crop/livestock yields per season on 1 hectare? (kg/acre)
2. **POST-HARVEST LOSS (PHL):** By implementing the CSA practice, what are the expected reductions in (pre- and post-harvest) losses of crops and livestock? Every season on 1 hectare? (kg/acre)
3. **INCOME GENERATION (INCG):** By implementing the CSA practice, what are the expected changes in income and/or profits per unit of area? ($/acre/ season or year)

Adaptation/resilience capacity

4. **WATER USE EFFICIENCY (WUE):** By implementing the CSA practice, what are the expected changes in the efficiency with which water is used? Scale: -10 = less efficiency / +10 = greater efficiency. Refers to water used for crop irrigation and/or livestock production. (L/kg of product/season)
5. **GENDER SMARTNESS (FOCUSING ON WOMEN) (GDR):** By implementing the CSA practice, what are the expected changes in participation in decision-making, income, free time, reduction in labour, time spent in the field and/or distance traveled by women for agriculture-related activities? Scale: -10 = huge positive effect / +10 = huge negative effect.
6. **CLIMATE RISK MANAGEMENT AND PREVENTION (CRM&P):** By implementing the CSA practice, what are the expected changes in farmers' capacity to manage, avoid and/or withstand climate risks and hazards (e.g. drought, floods, and dry spells) related to the value chain?
7. **DIVERSIFICATION OF INCOME SOURCES (DIS):** By implementing the CSA practice, what are the expected changes in the level of diversification of farmers' agricultural activities on a crop/livestock farm? (number of agricultural/economic activities on the farm)

Mitigation

8. **BIOMASS (ABOVE-GROUND) *(AGB):** By implementing the CSA practice, what are the expected changes in the availability of above-ground biomass (AGB: trees, shrubs, grasses and other vegetation) within the production system? AGB: All living biomass above the soil such as trees, crops, grasses, tree litter, seeds. E.g., a forest can accumulate more AGB than a desert. (ton/season/ha)
9. **SOIL CARBON STOCK (SCS):** By implementing the CSA practice, what are the expected changes in the quantity of organic matter accumulated in soil in areas under crop/livestock? (% or kg/ha or kg/m^3)
10. **NUTRIENT USE EFFICIENCY (NUE):** By implementing the CSA practice, what are the expected changes in the amount of macro and micronutrients available for plants in the soil?

[4] The complete list of CSA indicators proposed can be found in Annex 4.

CSA practices assessment

Based on the selected indicators, the top 4 CSA practices for each production system were evaluated in round tables using a qualitative scale from -10 to 10 (see explanation in Table 4). The average smartness scores by price are displayed in the table below, aiming to understand whether the same practice could have contrasting effects in diverse agro-ecological zones (AEZs) and socio-economic conditions of farmers previously recognized by participants. However, no major relevant differences were found between zones, except for cases such as improved drainage systems for cassava and coconut in Region 3.

Table 4. CSA practices ranking based on average score by region.

Region	Production System	CSA Practice	Smartness Score Average		Rank
			Zone A	Zone B	
3	Cassava	Improved drainage systems	6.3	6.7	1
		Water efficient irrigation	6.2	6.2	2
		Use of climate resilient varieties	4.4	4.4	3
		Community seed bank	4.1	4.1	4
	Coconut	Use of climate resilient varieties	7.8	7.8	1
		Improved land drainage systems	7.8	7.5	2
		Diversification of coconut varieties	6.8	6.7	3
		IPM (biological control, trap crops)	6.7	6.6	4
	Pineapple	Water reservoirs/ponds and irrigation + pumps	9	9	1
		Climate resilient varieties (Monserrat)	7.2	7.2	2
		IPM: Intercropping plantain and/or Sorrel	7.1	7.1	3
		Plant nurseries	7	7	4
	Plantain	Improved land drainage (excavation/drains)	8	7.9	1
		Improved irrigation systems (e.g. Sprinkler)	7.7	7.7	2
		Planting time	7	7	3
		Mulching /Cover crops	5.7	5.4	4
	Sweet potato	Improved drainage systems	9.1	9	1
		Use of climate resilient varieties	8.3	8.3	2
		Water efficient irrigation systems	8.3	8.3	3
		Use of rain water reservoirs	6.6	6.6	4
	Rice	Use of climate resilient varieties	6.4	6.4	1
		Disease resistance varieties e.g. Blast	4.8	4.8	2
		Produce and use clean seeds	4.8	4.8	3
		IPM Biological control, monitoring	3.7	3.8	4
9	Cassava	Crop Rotation with beans/pumpkin/watermelon	6.4	6.4	1
		Improved drainage systems	4.7	4.8	2
		Planting dates	3.8	4	3
		Small-scale equipment for cassava flour production	3.8	4	4
	Cashew nut	Tree mgmt. (pruning)	8.4	8.4	1
		Water harvesting	8.4	8.4	2
		IPM: Field sanitation	8.1	8.1	3
	Peanuts	Crop Rotation with red beans	8.1	8.1	1
		IPM: Keep areas of natural habitat (Natural predators)	7.7	7.7	2
		IPM: Biological control (Neem)	7.4	7.4	3
		Coordinated planting schedule	7.3	7.3	4
	Plantain	Intercropping with Cassava/pumpkin/watermelon	8.2	8.2	1
		Improved drainage systems	7.1	7.1	2
		Support suckers for plants	6.7	6.7	3
		Field sanitation	6.6	6.4	4
	Rice	Improved drainage system	8	8	1
		Time of planting	7.5	7.5	2
		Adequate Fertilization (timing, source, amount and placement)	6.3	6.3	3
		Land preparation for water conservation (incorporate crop residues and leveling)	4.2	4.2	4

Qualitative evaluation scale

Other <-10	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	Other >10

Completely negative effect (-100% compared to baseline) — Medium negative effect (-50% compared to baseline) — No change / NA (0% compared to baseline) — Medium positive effect (+50% compared to baseline) — Completely positive effect (+100% compared to baseline)

The smartness scores also served to rank the top four list of CSA practices that will be used to advance to phase 3. Where, unlike the multidimensional evaluation, the values obtained through CSA indicators for the same practice and crop in each region, show that potential impacts are diverse depending on the context where the practice is implemented, the differentiating characteristics stated by participants (Table 1) help to explain the variation in the results. In a regional basis, the pool of priority CSA practices seem to present greater potential benefits in the indicators for both *food/nutritional security* and *mitigation* in Region 9, while the result is more promising for Region 3 in terms of adaptation. In any case, the general trend points towards CSA practices providing greater benefits for the adaptation pillar (increases in yield; post-harvest loss reduction; greater income generation). Followed by *food/nutritional security* (greater water use efficiency; balance in components of gender indicator; greater capacity for climate risks management and prevention; and diversification of income sources), and to a lesser extent for *mitigation* (increases in above-ground biomass and soil carbon stock; and greater nutrient use efficiency). Disaggregated results by practice and pillar are presented in Figure 5.

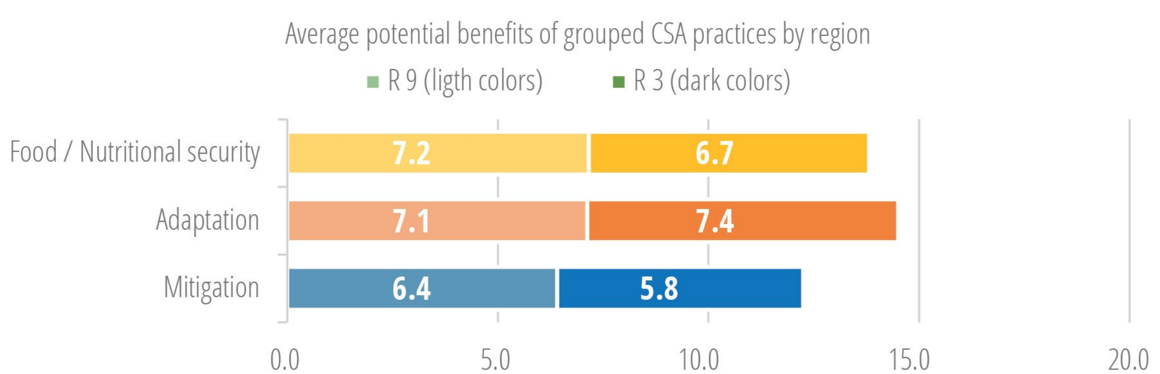


Figure 4. Average potential benefits of grouped CSA practices by region.

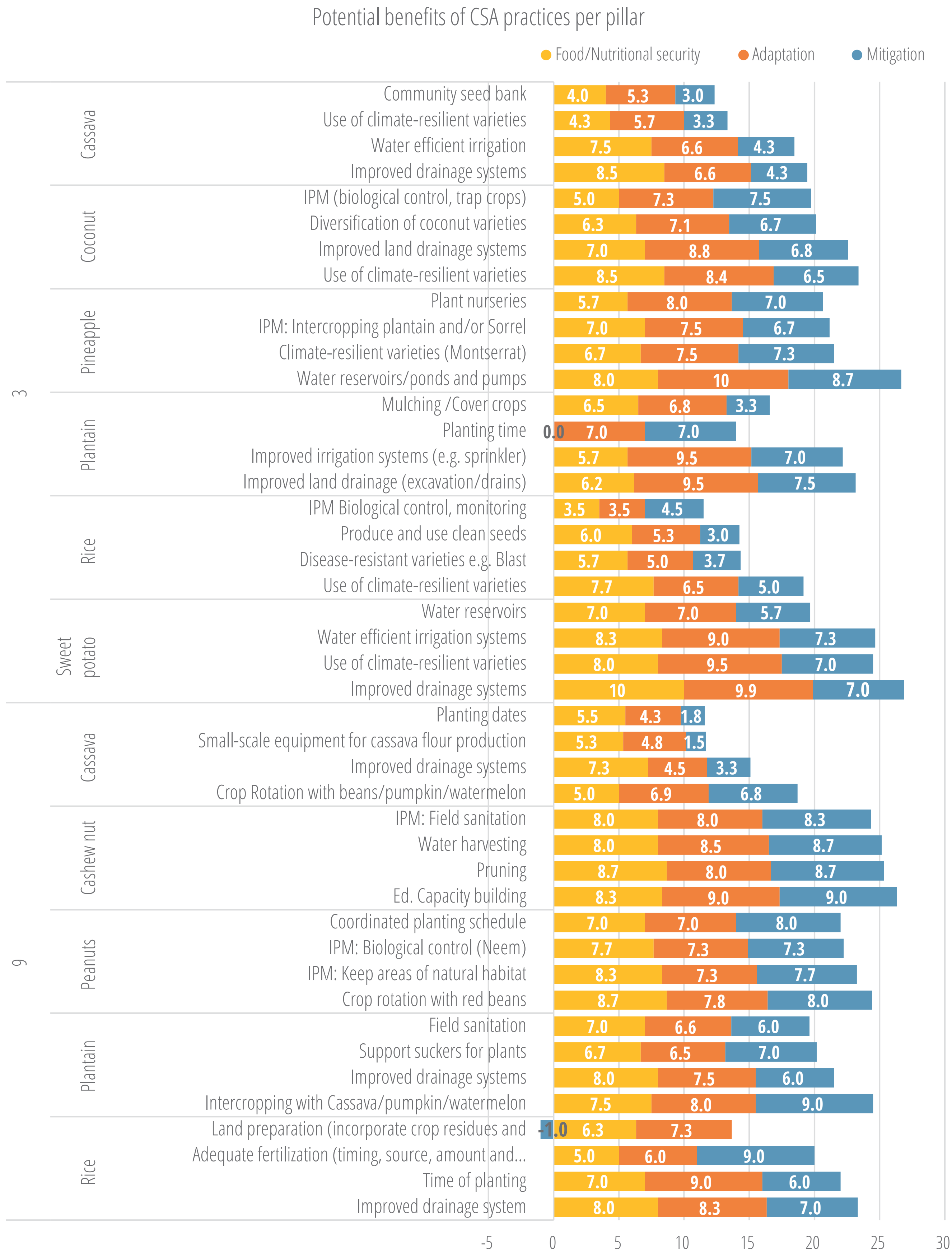


Figure 5. Potential benefits of CSA practices per pillar and region.

Phase 3. Understanding the costs and benefits of adopting CSA practices

The third phase – economic analyses of available options – aimed to assess the financial costs and benefits of the top 24 CSA options prioritized during the previous phases, considering the scope and resources available, the cost-benefit analysis (CBA) was applied to the top two options per crop and region.[5] The analysis mainly reflects the private profitability (farmer oriented), but also seeks to capture social benefits by incorporating an estimation of carbon and biodiversity externalities of the CSA practices and production systems analysed. This information was complemented by a sensitivity analysis to determine how the financial profitability of the CSA practices is affected based on changes in input variables such as discount rate or market price, helping to simulate how financial indicators are dependent on particular internal and external factors.

A standard application of CBA was carried out using the criteria established by the European Commission (2010), and adapting the methodology implemented in previous CSA-PF projects according to Saín et al., 2017 (Figure 6). The raw data was collected mainly through Focus Group Discussions (FGD), carried out in September 2019 at NAREI's offices in Georgetown, and complemented through consultation with local experts and review of specialized and scientific literature.

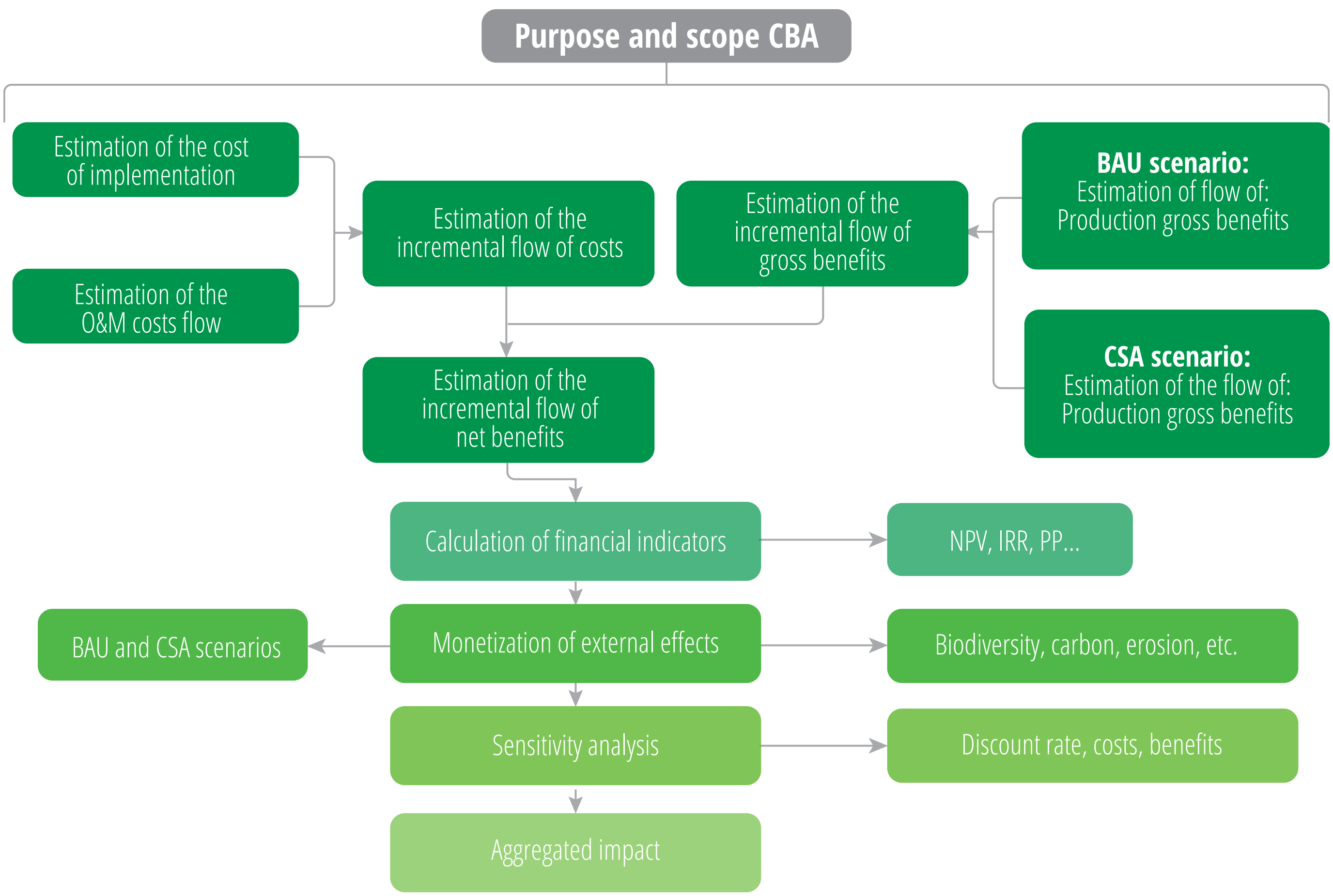


Figure 6. CBA structure, purpose and scope in Guyana.

[5] The top 2 options were further detailed and consulted with experts in order to get details and recommendations in the case of rice in Region 3.

A total of six financial indicators such as the net present value (NPV), the benefit-cost ratio (B/C), the internal rate of return (IRR), the payback period (PP), as well as the implementation and maintenance costs for each CSA practice were calculated (see complete explanation in Annex 3).

It is worth mentioning that in the case of Cashew nut in Region 9, experts during the FGD for CBA data collection pointed out that this species is still cultivated in a very low-tech way, almost wild, being mainly for household self-consumption, without any particular type of agronomic management practices. This may imply that an investment in any evaluated CSA option for this crop, and its production system, represents a new cost that could be reflected as a financial disadvantage for the farmer, but it must be interpreted under the context of the assessment in BAU and CSA scenarios. Therefore, it makes difficult to evaluate the practices for this crop through the classical profitability indicators, since the lack of participation predominates in a relatively stable or developed value chain/market around this product. However, different actors have already recognized this crop during the prioritization process (and in other scenarios) as a non-traditional crop with great potential for the development of the rural economy and that of small-scale farmers (FAO and CDB, 2020; Hiwale, 2015; CATS and ACi, 2014; MoA, 2013). Therefore, any investment to strengthen the agricultural activity around the cashew nut must consider a strong public-private strategy of technical and financial support.

In order to simplify the analysis and interpretation process, the data was standardized to one acre – the most common area measure in Guyana. For each crop, the natural cycle (i.e. productive life cycle) was considered; however, it is assumed that crops are grown year after year (in the case of annual crops) and/or maintained (perennial crops) until completing a 10 years period. This is adjusted to equate cash flows with the longest productive cycle of the crops analyzed. This, in order to compare all cash flows within a similar time frame. Thus, all CBA indicators (NPV, IRR, etc.) were calculated for a 10 years period.

BAU private costs for farmers

The cost reported for the BAU scenario comprised the expenses incurred by farmers in implementing and maintaining conventional farm activities in a standard area of 1 acre in 1 year. Higher total production costs (implementation + maintenance) correspond to pineapple, plantain, and sweet potato for Region 3 and rice for Region 9, respectively. Total production costs were lower in Region 9 for the same crops as in Region 3 (82% for rice and 20% for cassava), except for rice, which was higher by 29%. This pattern may be influenced by the differences between famers' level of technification and the degree of crop management by the farmer, as well as by the type of cropping system in each region[6].

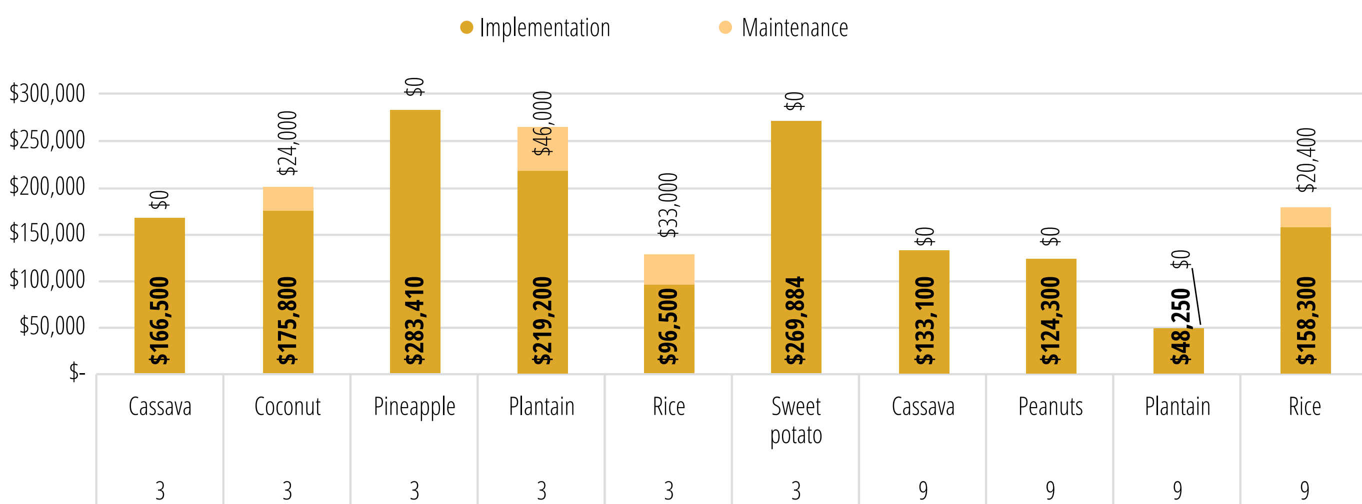


Figure 7. Implementation and maintenance costs under the BAU scenario.

[6] In general, the agricultural production systems in Region 3 tend to be market-oriented, meeting the needs of the country's most populated areas. While Region 9, which has a savannah-based agriculture, has the potential to sustainably develop its local agricultural market to meet its own needs.

BAU Private benefits for farmers

The CBA analysis for the BAU scenario revealed that for, both regions, farmers' agricultural activities, particularly for the studied crops projected to a 10-year production cycle, proved to be a profitable option, except for rice production in Region 9, which presented a negative NPV meaning that production costs exceeded the perceived benefits for this crop in particular. This is partly explained by the high production costs – as mentioned above – which cannot be compensated by the income obtained from its sale. Other factors, such as low productivity (28 bags/acre) vs. 80 bags/acre as reported in Region 3, also explain this finding. The financial indicators for this scenario are presented in Table 5:

Table 5. CBA for BAU scenario in Region 3 and Region 9.

Region	Crop	Practice (GYD)	Total production cost (GYD)	Total net income	NPV (GYD)	B/C	IRR (%)	IRR annual (%)	PP (years)
3	Cassava	-	1,831,500	4,764,860	2,619,828	3.6	296	29.6	0.7
	Coconut	-	439,800	3,088,200	1,301,784	8	54	5.3	0.4
	Pineapple	-	1,983,870	18,896,130	10,417,256	10	281	28.1	0.9
	Plantain	-	2,917,200	12,382,800	6,881,202	5.2	477	47.7	0.8
	Rice	-	1,424,500	1,055,500	540,051	1.7	91	9.1	0.9
	Sweet potato	-	2,968,724	14,992,076	8,353,464	6.1	566	56.6	0.8
9	Cassava	-	1,464,100	581,350	270,580	1.4	53	5.3	0.1
	Peanuts	-	1,367,300	1,632,700	868,444	2.2	141	14.1	0.3
	Plantain	-	530,750	2,378,340	1,322,827	5.5	503	50.3	0.8
	Rice	-	1,833,700	(993,700)	(633,973)	0.5	-	-	-

CSA private costs for farmers

The CSA scenario comprised the cost associated with implementing and maintaining CSA practices scaled to 1 acre during their lifetime. To facilitate comparison between measures, these were grouped by quartiles[7] according to the initial investment costs across the regions (Figure 8). This is important because it provides a better understanding of the range of initial costs that farmers may need to assume or would require finance support as it is one of the most common limitation that farmers face when implementing and adopting a CSA practice as it will be discussed in the Barriers and Opportunities section. On a per-acre basis, the higher cost range was mainly for improved drainage systems for both R3 and R9, where this practice was identified as a suitable option according to the local climatic hazards. Medium-cost practices corresponded to improved/water efficient irrigation systems, e.g. sprinkler, drip, etc.[8] All remaining practices that are not necessarily related to infrastructure and focus, instead, on agronomic crop management practices occupy the low-cost range[9]. On the other hand, IPM-monitoring, time of planting, and production and use of clean seeds for rice, and use of climate-resilient varieties for sweet potato were identified by experts as options that could not represent significant additional investment costs in the context of the assessment – unless, just to mention an example, the cost of the clean seed was higher than that assumed in BAU, or that achieving a proper implementation of the identification of sowing dates could represent additional costs for producers in terms of new activities, materials, etc.

[7] The distribution is as follows: Q3 ≤ GYD 162,900; Q2 ≤ GYD 85,000; Q1 ≤ GYD 36,000.
[8] Irrigation systems, particularly sprinklers, might not be a highly efficient irrigation system, but they have to be compared to the baseline in the analysis context. For instance, flood irrigation represents an improvement in the system, although it is possible to use micro-sprinkler or drip irrigation systems, which achieve greater water savings.
[9] Proposed cost ranges are based on prices reported by the focus group, and these can vary between crops and between regions.

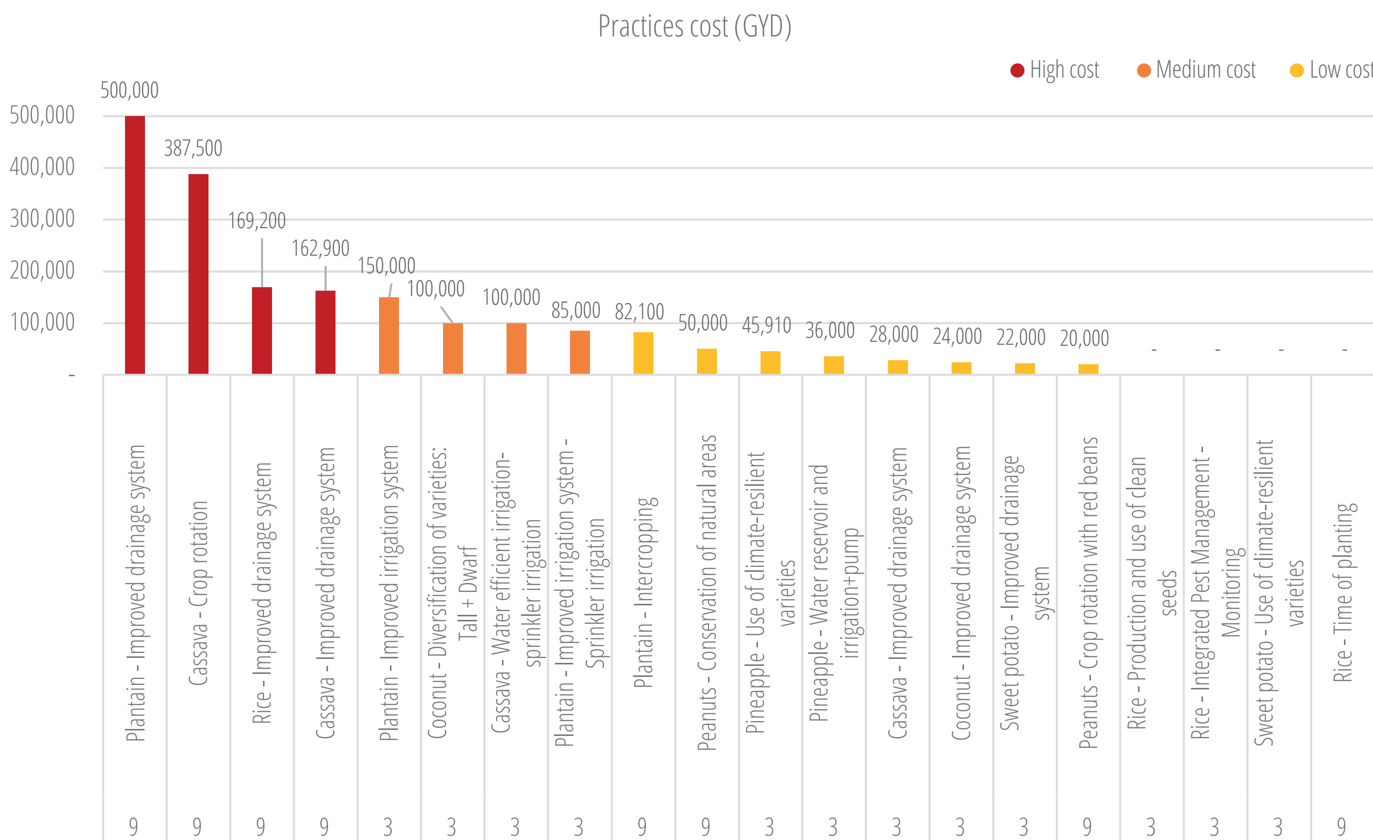


Figure 8. Practices cost in Region 3 and Region 9.

CSA private benefits for farmers

The private cost-benefit analysis shows that, except for cassava (crop rotation) in Region 3 and rice (Improved drainage system and time of planting) in Region 9, all CSA practices evaluated are efficient from an economic point of view for farmers under the assumptions and context of the study.[10] These exceptions showed a negative NPV, and their IRR was lower than the opportunity cost of money, i.e. the discount rate.

Among the practices that presented a positive NPV, the values ranged from GYD 432,048 for improved drainage systems in cassava (Region 9) to GYD 12,561,015 found in pineapple (Region 3). This means that the difference between the present value of cash inflows and the present value of cash outflows over the 10 years of analysis is positive. As a complement to this result, the IRR values also showed positive values greater than the discount rate (12%), indicating that the potential increase in crop yield attributable to each measure[11] increases farmers' income and overcome their implementation costs. Positive IRR values were between 39% and 566%, showing that the relationship between investment and profit is financially attractive. However, high IRR values must be interpreted conservatively, considering the context and assumptions of the study (see Assumptions section). The C/B ratio greater than 1 in positive cases reinforces the potential that all projects can deliver a positive NPV.

[10] Complete cash flows and detailed analysis are available at request at m.lizarazo@cgiar.org
[11] Yield reported for BAU and CSA scenarios and yield gap are listed in Annex 2.

In the case of payback period (PP), it ranged from 1.3 to 4.3 years in Region 3, and 1.2 to 3.8 years in Region 9. This period of time is related to the type of crop, i.e. annual, semi-perennial, and perennial. For instance, in annual crops, PP shows that two or more continuous harvests are required to recoup investment in CSA practices, while in perennials, such as coconut, the investment in evaluated CSA practices can be recovered between in 4.1 and 4.3 years. On average for all practices in both regions, the PP is 2.4 years, which can imply a rather long period for small-scale farmers who depend on the planting of a single crop. With this in mind, it is important that agricultural stakeholders work collectively and actively towards the construction of an enabling environment for the adoption of CSA practices. This, according to Ng'ang'a et al. (2017), should include security of land tenure, low interest rates for credits, short-term livelihood options, a broad base of plant genetic resources (adapted to local conditions), and diversification with plant or animal species, among other alternatives.

Table 6. CBA for CSA scenario in Region 3 and Region 9.

Region	Crop	Practice	Practice cost*	Total Net Income	NPV	B/C	IRR (%)	PP (years)
3	Cassava	Improved drainage system	84,000	6,065,590	3,320,237	4.2	280	1.4
		Water efficient irrigation - sprinkler irrigation	300,000	6,773,590	3,678,872	4.2	222	1.3
	Coconut	Improved drainage system	72,000	3,016,200	1,252,838	6.9	50	4.3
		Diversification of varieties: Tall + Dwarf	1,100,000	3,001,975	1,201,158	2.9	42	4.1
	Pineapple	Water reservoir and irrigation + pump	72,000	23,000,130	12,561,015	12.2	275	2.6
		Use of climate-resilient varieties	505,010	22,567,120	12,309,942	10.1	263	2.6
	Plantain	Improved drainage system	900,000	12,859,800	7,056,193	4.4	303	1.8
		Improved irrigation system - Sprinkler irrigation	510,000	14,167,800	7,792,987	5.1	380	1.6
	Rice	Production and use of clean seeds	-	1,055,500	540,051	1.7	91	2.9
		Integrated Pest Management - Monitoring	-	1,303,500	662,817	1.9	98	2.7
	Sweet potato	Improved drainage system	66,000	17,716,556	9,835,121	6.8	544	1.6
		Use of climate-resilient varieties	-	14,992,076	8,353,464	6.1	566	1.8
9	Cassava	Crop rotation	1,162,500	(132,394)	(214,228)	0.9	-	-
		Improved drainage system	162,900	1,032,090	432,048	1.6	39	3.4
	Peanuts	Crop rotation with red beans	60,000	2,956,700	1,589,515	3.1	178	1.2
		Conservation of natural areas	550,000	1,982,700	1,011,670	2.0	101	2.8
	Plantain	Intercropping	328,400	2,313,940	1,260,256	3.7	202	1.5
		Improved drainage system	500,000	2,169,250	966,834	3.1	46	3.8
	Rice	Improved drainage system	169,200	(28,900)	(203,745)	1.0	(1)	-
		Time of planting	-	(129,700)	(177,266)	0.9	(11)	-

Negative NPV results found for certain CSA practices in rice and cassava, under the assumptions of the study, do not mean that they cannot become viable projects if one or more of the parameters of the analysis becomes more favorable for the producers, for example, through better yields, lower implementation costs, better market prices or their combined effect. However, it is always difficult to capture with absolute certainty all the universe of possible risks involved in the implementation of CSA options. A comparative analysis of the total NPV by practice, crop and region can be found in the following figure.

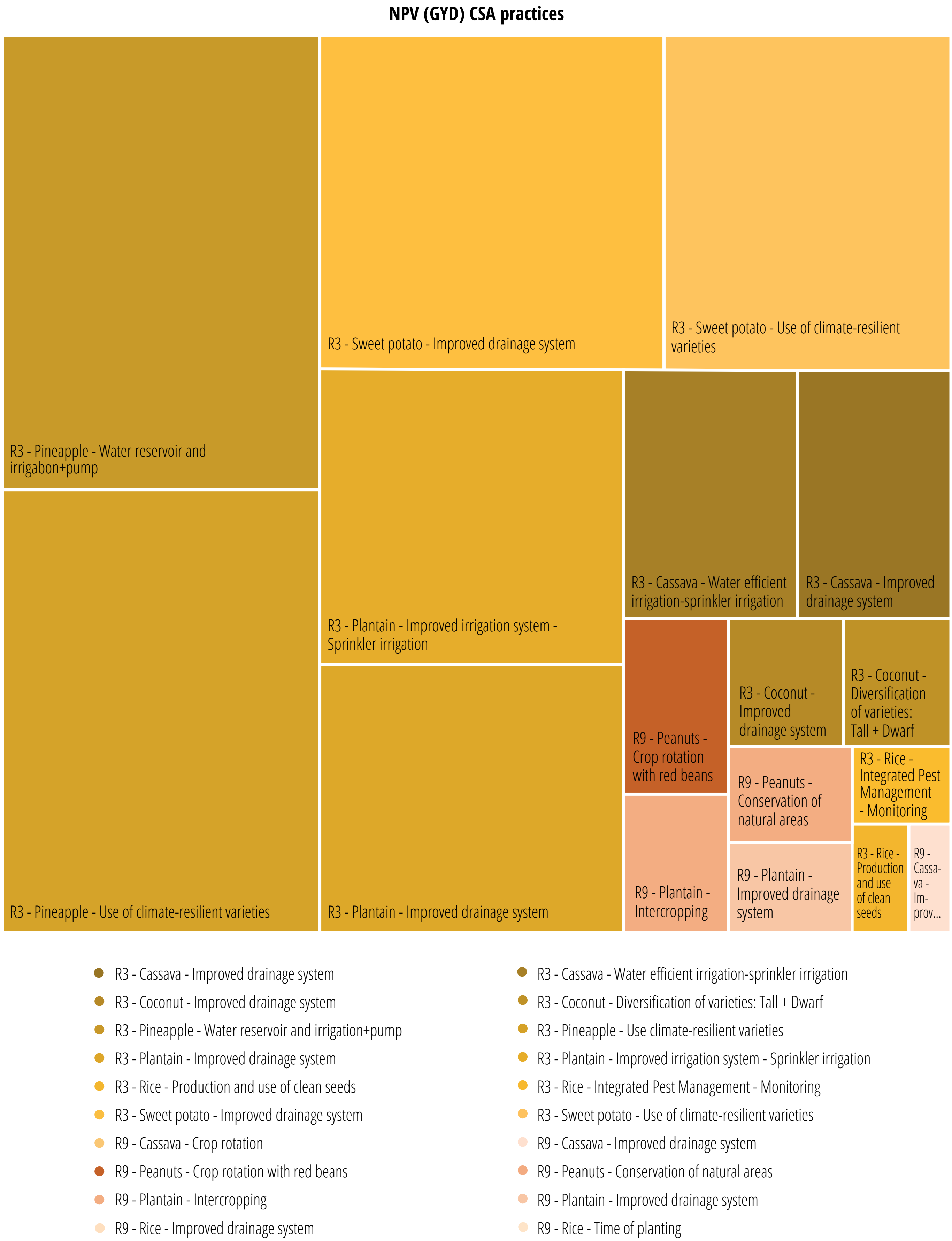


Figure 9. Total NPV by practice by crop by region.

Environmental externalities

The implementation of CSA practices can generate positive side effects both in the social and environmental spheres. In our case, the focus was on environmental benefits. Quantitative estimates for all CSA activities were presented in terms of carbon capture and biodiversity (landscape heterogeneity).[12] The results of potential additional income calculated through shadow prices method – as described in the methodological section – for each crop and in each region, are presented in the Figure 10.

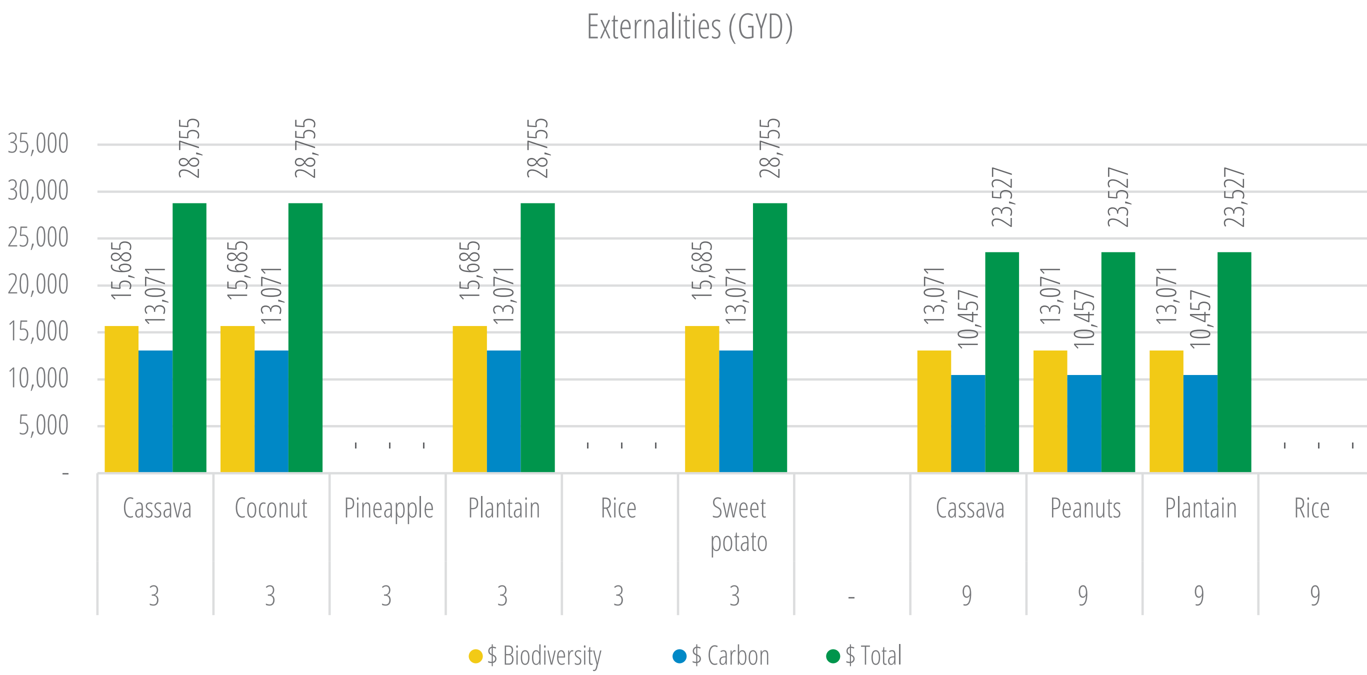


Figure 10. Externalities (potential additional income in GYD).

Results showed that the implementation of CSA practices are capable of transforming cropping systems, converting one category of land use into another with greater potential to generate ecosystem services, such as carbon capture and biodiversity conservation, thus creating value in the economic sphere. Measures such as crop rotation, intercropping, diversification of varieties, water efficient management, e.g. irrigation systems and conservation of natural areas – as prioritized for sweet potato and coconut for Region 3, peanuts for Region 9, and plantain and cassava for both regions. However, it is difficult to materialize the mentioned value in monetary terms reaching farmers outside of any specific project or payment for environmental services scheme. For this reason, in a desirable future, where national policies and mechanisms that enable payment of these environmental services and their internalization in farmers' economy, the additional income generated could achieve a relative improvement in the profitability of their agricultural activities.

A hypothetical internalization of the value generated through the monetization of externalities, which refers to the inclusion of additional income in the cash flow of the practices, was assumed to determine how it affects the profitability indicators in each practice. See table below.

[12] Complete methodological procedures can be found in CBA report for Regions 3 and 9 in Guyana.

Table 7. Internalization of potential income from externalities and profitability indicators.

Region	Crop	Practice	Practice cost*	Total Net Income	NPV	B/C	IRR (%)	PP (years)
3	Cassava	Improved drainage system	84,000	6,353,144	3,482,712	4.2	294	1.5
		Water efficient irrigation-sprinkler irrigation	300,000	7,061,144	3,841,346	4.2	232	1.3
	Coconut	Improved drainage system	72,000	3,303,754	1,415,313	6.9	57	8.5
		Diversification of varieties: Tall + Dwarf	1,100,000	3,289,529	1,363,633	2.9	47	8.3
	Pineapple	Water reservoir and irrigation+ pump	72,000	23,000,130	12,561,015	12.2	275	2.6
		Use of climate-resilient varieties	505,010	22,567,120	12,309,942	10.1	263	2.6
	Plantain	Improved drainage system	900,000	13,147,354	7,218,667	4.4	310	1.8
		Improved irrigation system - Sprinkler irrigation	510,000	14,455,354	7,955,461	5.1	388	1.6
	Rice	Production and use of clean seeds	-	1,055,500	540,051	1.7	91	2.9
		Integrated Pest Management - Monitoring	-	1,303,500	662,817	1.9	98	2.7
	Sweet potato	Improved drainage system	66,000	18,004,110	9,997,595	6.8	554	1.6
		Use of climate-resilient varieties	-	15,279,630	8,515,938	6.1	576	1.8
9	Cassava	Crop rotation	1,162,500	102,877	(81,294)	0.9	6	-
		Improved drainage system	162,900	1,267,362	564,982	1.6	47	3.8
	Peanuts	Crop rotation with red beans	60,000	3,191,971	1,722,448	3.1	193	1.2
		Conservation of natural areas	550,000	2,217,971	1,144,603	2.0	113	0.9
	Plantain	Intercropping	328,400	2,549,211	1,393,189	3.7	220	1.6
		Improved drainage system	500,000	2,404,521	1,099,768	3.1	51	(0.1)
	Rice	Improved drainage system	169,200	(28,900)	(203,745)	1.0	(1)	5.3
		Time of planting	-	(129,700)	(177,266)	0.9	(11)	-

Additional income from externalities represented an average increase of 5.5% in the Net Present Value for crops in Region 3 and 15.3% in Region 9. Likewise, IRR values rose by 9% and 11% in Region 3 and in Region 9, respectively. There were no significant changes in the PP between both CSA and CSA + Externalities scenarios. Notwithstanding the overall increase in private profitability, the negative income pattern was maintained for cassava and rice in Region 9 – these only achieved a slight improvement, without reaching the breakeven point of investment. This can be explained because the category of land use in these cases corresponded to annual crops without any major impact on externalities, and due to the nature of the practices identified for these crops, it was not possible to significantly change this result either.

In summary, the CSA practices that can achieve significant effects on externalities are those that allow diversification of the agroecosystem, including semi-perennial and permanent species (preferably woody), whose cropping system can best mimic a primary forest or at least the reference ecosystem of the region.

Sensitivity Analysis

The sensitivity analysis was carried out to reveal how sensitive the results of the economic indicators are to a change in the variables that make up the model. Given the dynamic and fluctuating nature of the economic information/variables, it is important to explore possible changes in these parameters to identify those that may have a greater influence so that CSA interventions are economically viable or not. In this case, three sources of variation affected the NPV, namely the discount rate (DR) (10%, 12%, and 14%) as well as an increase in market prices and a reduction in production costs of 5% and 10%, as well as a combined effect that adds the two above-mentioned variables. With this in mind, two scenarios of analysis were evaluated: optimistic and challenging scenarios.

Optimistic scenarios

Most CSA practices are still economically viable options under 10% and 12% discount rate scenarios, even with a challenging 14% discount rate. The only case where the combined effect (10% increase in market price and 10% reduction in production costs) produced a negative value was in Region 9, particularly improved drainage systems in rice, meaning that under this scenario the practice will probably not yield a positive economic return. This situation could be attributed to the fact that the rice production model is not exclusively focused on generating surplus for sale, as it is not a staple crop, implying a relative low-technical crop management strategy, hence low crop yield. In addition, the agroclimatic layer is another adverse context-specific factor, i.e. erratic rainfall patterns and annual rainfall, high temperature, and/or pest and disease outbreaks, that results in limiting local production. Under a combined effect, the NPV decreases as the discount rate (DR) increases. That is to say, under a 10% DR, the NPV increases on average 32% and 46% in Regions 3 and 9, respectively. In the same order, using the 12% DR, the NPV increased by 20% and 32%, and under a 14% DR, the average NPV increased only by 9 and 19% in R3 and R9 accordingly.[13] (Detailed results of sensitivity analysis are available at request at m.lizarazo@cgiar.org).

Challenging scenarios

In a less optimistic scenario, when evaluating the NPV under a combined effect (5% reduction in market price and 5% increase in production costs), results showed – as in the optimistic scenario – that CSA practices for both crops, cassava (crop rotation) and rice (improved drainage systems and time of planting) in Region 9 continued to experience difficulties to be economically viable investments, particularly, when testing values greater than or equal to 5% for the mentioned parameters, and considering the contextual characteristics of the agricultural production system as described above for this region.

Only a 2% increase in NPV is achieved in Region 3 with a 10% DR, while in Region 9 the NPV contracts 26%. A 12% DR caused NPV reductions of 10% and 16% in Regions 3 and 9, respectively. In parallel, the most challenging scenario (a 14% DR and a combined effect) continues to show positive NPV, but in average its magnitude, compared to the CSA scenario, was reduced by 19% in Region 3 and 25% in Region 9.

The above indicates that relatively small changes in market conditions can cause crop profitability to decline. Therefore, strategies can be projected from both farmers and decision makers to increase resilience through actions (including CSA practices) that focus on regulating and guaranteeing, as far as possible, fair input costs and produce prices, as well as affordable and competitive discount rates that make agricultural credits viable instruments to boost agricultural activity. Figure 11 shows the effect of the various discount rates (DR) in percentage (%) and the combined effect on NPV (GYD) in both optimistic and challenging scenarios for each CSA practice.

[13] For CSA practices that presented negative NPV, the combined effect produced increases greater than 100% in both regions, becoming the NPV positive.

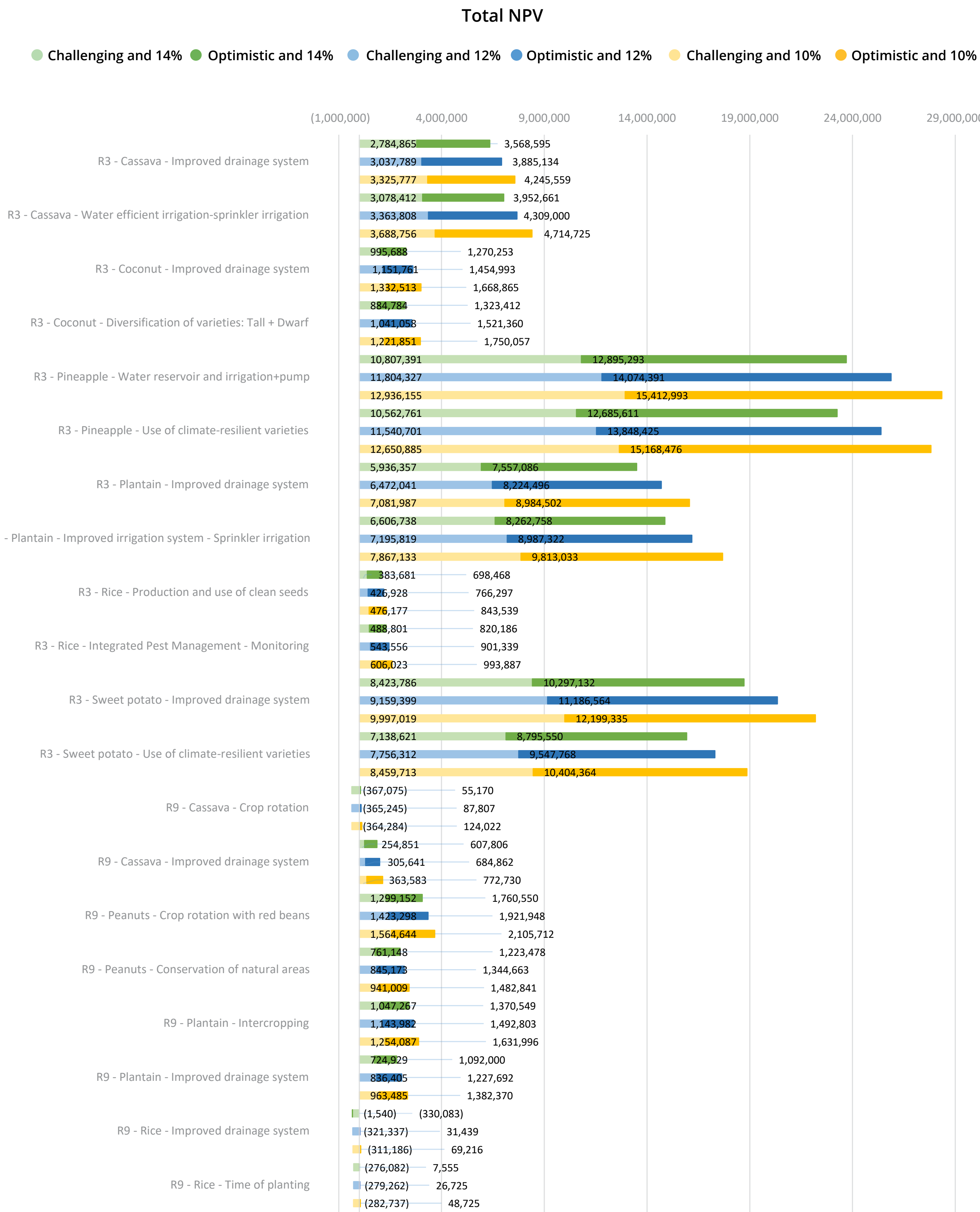


Figure 11. Total NPV (GYD) under optimistic and challenging scenarios and three discount rate percentages (10%, 12%, 14%).

Phase 4. Co-design of CSA investment portfolios

During the fourth phase, two 2-day workshops were held in Lethem and Georgetown in December 2019. The workshops brought together stakeholders from local civil and public institutions and organizations related to the agricultural sector to inform about the project context and status, and to build on the results of the previous phases. The work carried out previously through the CFS-PF was then resumed, broadening the understanding of the objectives and scope of the process, as well as exploring the various technical criteria addressed by the prioritization methodology (Figure 12). This involved a detailed review of the costs and benefits – including externalities – of the prioritized measures in Phase 3, the climate smartness of each measure – evaluated through the CSA indicators –and the addition of a third prioritization criterion, which focused on the identification and assessment of multidimensional[14] barriers to adoption of CSA priorities in the territories, but also the potential opportunities to overcome these barriers, as described in the following section.

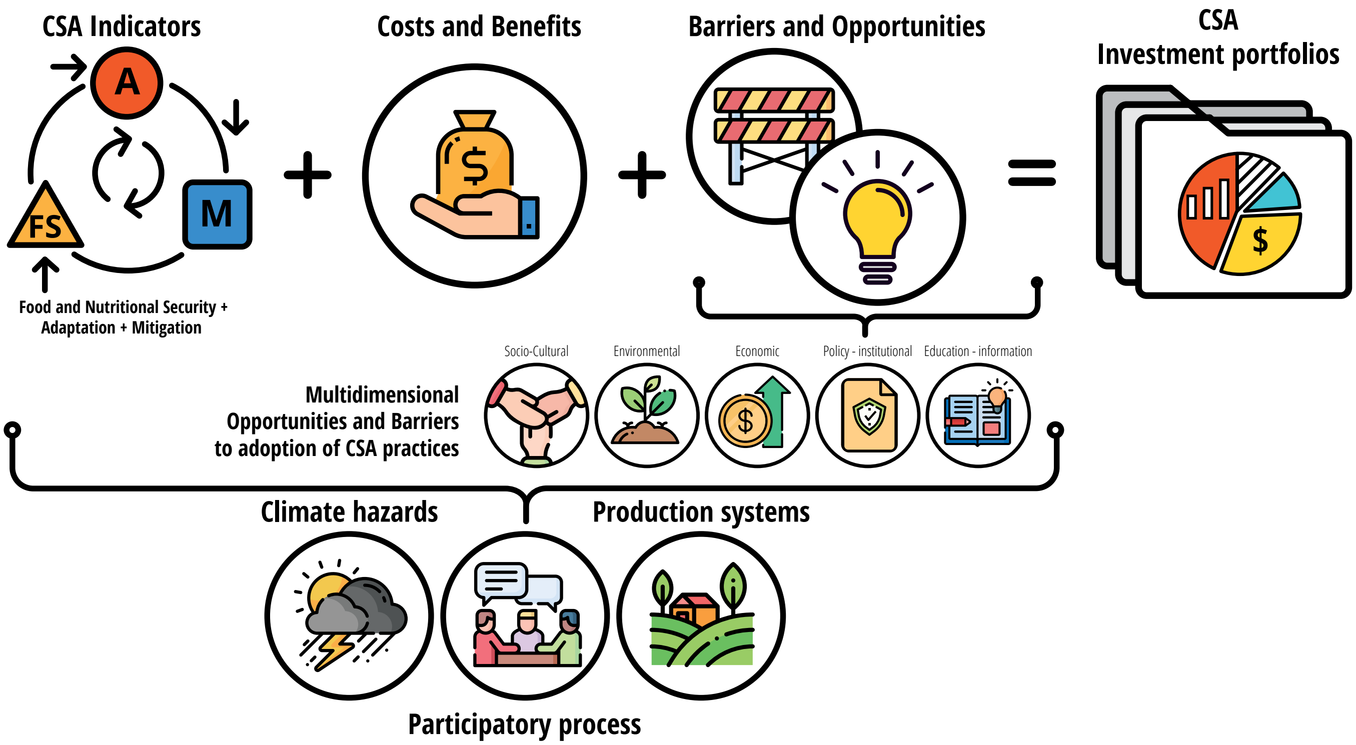


Figure 12. Main prioritization criteria of the CSA-PF.

Opportunities and Barriers (B&O) to adoption of CSA practices

During the second workshop, the participants identified a series of Barriers (B) that CSA practices face in the context of each region, considering socio-cultural, environmental, economic, political/institutional, and educational/ information dimensions. In parallel, the participants were also inquired about the possible current and future Opportunities (O) – if they exist – that should be explored to improve the enabling environment to overcome the identified barriers for each practice, aiming to consolidate an effective adoption of the practice by farmers. They

[14] Multidimensional refers to an approach in which participants observe, interpret, and analyze complex situations or problems, integrating various points of view, in this case, from layers such as socio-cultural, environmental, economic, political / institutional, educational / information.

were asked to identify a maximum of 10 barriers and 10 opportunities in order to have a comparable evaluation scale for this criterion.[15] A qualitative evaluation scale from 0 to 10 was used to determine how difficult it is to overcome a barrier (0 = Very easy to overcome / 10 = Very difficult to overcome) and how easy it is to seize an opportunity (0 = Very difficult to attain / 10 = Very easy to attain). The following formula expresses the calculation of the total B and O score (S) per practice.

$$S = (ai - aj) + \left(\frac{\sum_{i=0}^{n} m_i}{a_i} - \frac{\sum_{j=0}^{n} m_j}{a_j} \right)$$

ai = amount of opportunities
aj = amount of barriers
mi = magnitude of opportunities
mj = magnitude of barriers
n = amount of identified opportunities or barriers $n \leq 10$

The results suggested that in both regions there were identified barriers and opportunities for all the CSA practices in all proposed dimensions. CSA practices have both barriers and opportunities that point to a single dimension or the combination of two of them (multidimensional category), e.g. economic + political/institutional. The frequency of B and O identified by practice (Figure 13) suggests that, for single categories, around 20% of Barriers in both regions are political/institutional, followed by socio-cultural, and environmental for Region 3 and Economic for Region 9. However, in the opportunities scenario, Education/information represents the larger group, followed by political/institutional. There is a 0% of frequency in single categories for Regions 3 and 9; however, it does not mean that there are no opportunities, but instead they are coupled with another category, configuring the multidimensional category. Therefore, multidimensional barriers and opportunities represent the higher frequency in both regions, and it is worth mentioning that the percentage of recognized opportunities in most cases exceeds the barriers. A more detailed list of specific barriers and opportunities and their categories linked to the prioritized practices is shown in Tables 8 and 9 according to the participatory mapping exercise.

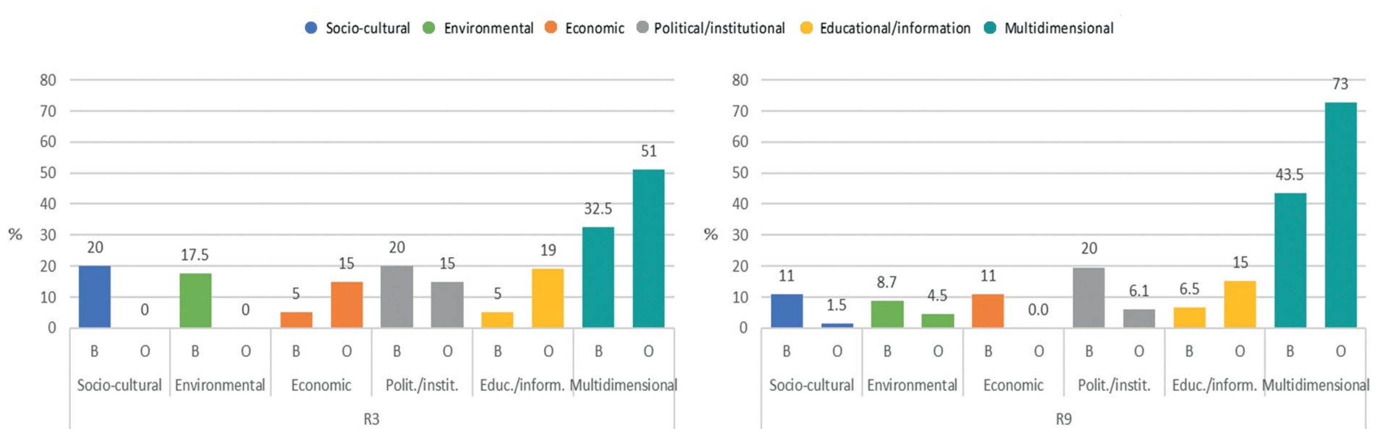


Figure 13. The frequency of B and O identified by practice and region.

[15] The calculation of the total B&O score (Index) is based on two parameters: a) the amount of barriers and opportunities identified per practice, and b) the perceived magnitude of difficulty in overcoming a given barrier and the ease of seizing an identified opportunity – a barrier can have none or more than one identified opportunity. The formula express the difference between the total amount of opportunities and the barriers (identified per practice), plus the difference between the average qualitative assessment of opportunities and barriers. S=0 the amount and magnitude between B and O is equivalent; S<0 the barriers outweigh the opportunities; and S>0 the opportunities outweigh the barriers.

In a comparative analysis between the number of barriers and opportunities for each CSA practice, the Score (S) was used to identify cases where the amount of barriers and the difficulty to overcome them, exceeded the amount of opportunities and ease of seizing them. From the twenty-two practices evaluated, only five of them presented negative scores (S) (see Figure 14).

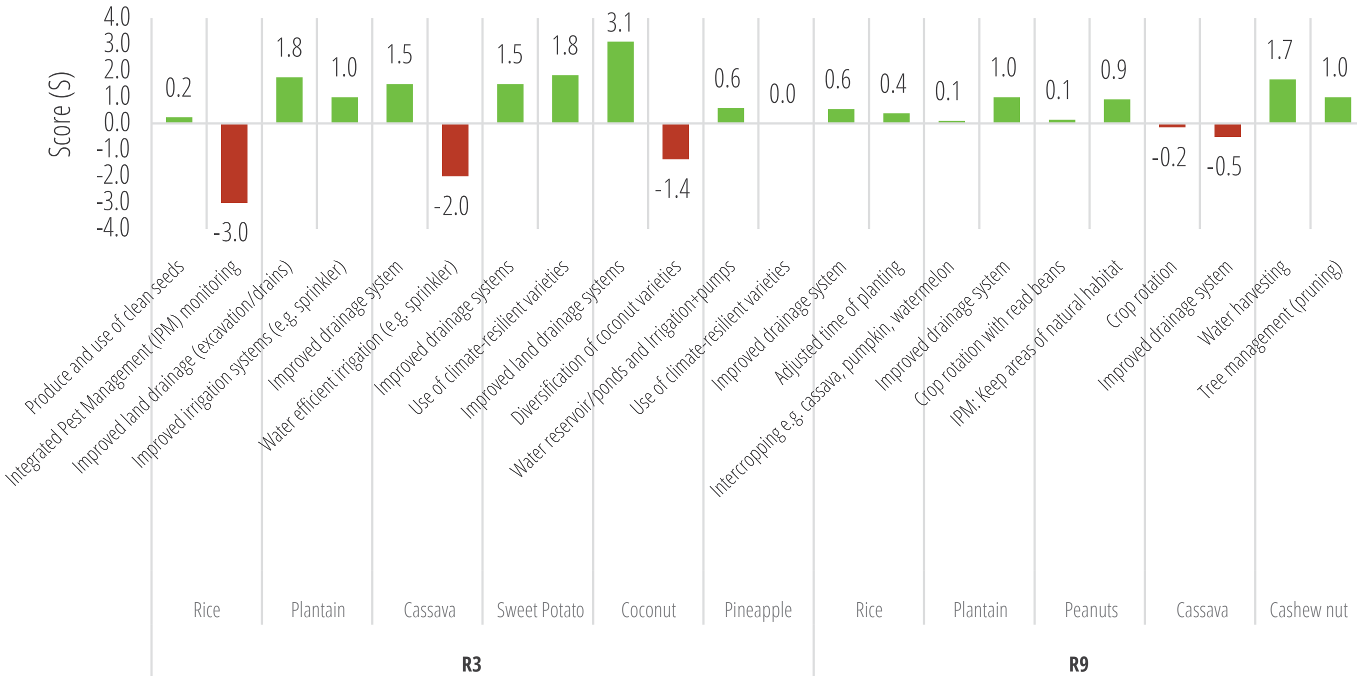


Figure 14. Barriers and Opportunities, total score (S) by practice and region.

Particularly in R3 for rice, cassava, and coconut, and in R9 for cassava only. In the case of Integrated Pest Management (IPM) for rice, the practice faces two barriers related to the use of agrochemicals for pest and disease management. From the socio-cultural perspective, participants stated that the "*change in the mind-set about spraying synthetic pesticides*" as well as a "*weak regulation and monitoring on use of synthetic pesticides*" – from the policy and institutional point of view – are complex situations. However, *enforcement of the regulations on synthetic pesticides sale and use*, accompanied by *reinforcement of IPM strategies such as biocontrols and biopesticides* may contribute to addressing these issues. In the case of cassava in R3, a key barrier refers to the "*Low awareness and access to financial and technical options*" to implement water efficient irrigation systems. This could be countered by a series of opportunities –with a medium difficulty level to be attained – such as spaces to *demonstrate their potential benefits in terms of productivity; strengthen training on alternative types of irrigation systems and water sources (wells), contourlines, and use of the slope in favour for irrigation; and increase financing opportunities and credit facilities*. For the same crop in R9, despite the fact that the number of opportunities for crop rotation and improved drainage systems was greater than the number of barriers, their average magnitude was slightly lower. This reveals the need to take action towards materializing activities that will allow attaining the proposed opportunities (see specific B and O in Tables 8 and 9). Finally, the diversification of coconut varieties (R3) faces some technical challenges related to the long time it takes to new varieties to be productive after planting, a limited availability of varieties, and potential cross breeding issues, in addition to a fragmented coconut industry. Nevertheless, the market demand is increasing due to growth in coconut – and its derivatives – consumption. Trend that should be accompanied by the establishment of a national board to supervise this industry, and as for the technical aspects at farm level, opportunities revolve around the activation of Farmer Field School (FFS), where knowledge and experiences in setting up own nurseries and farm zoning to avoid cross breeding can be shared.

Table 8. Barriers and Opportunities by CSA practice in Region 3.

REGION 3

	Crop_CSA Practice_Region	Type	Barriers 0= Very easy to overcome / 10= Very difficult to overcome	Score	Aver.	Type	Opportunities 0= Very difficult to attain / 10 = Very easy to attain	Score	Aver.	Total score
1	Rice_Produce and use of clean seeds R3		Farmers acceptance of new (improved) varieties	7	5.2		Demonstrate that improved varieties can generate greater yield	3	6.4	0.2
			Time required to develop new varieties	7			Farmer field schools for training on specific topics	8		
			Consumers knowledge and acceptance to new varieties	5			Look for seeds from other seeds growers in the community	9		
			Difficult access for farmers to seeds (time and distance)	8			Use less toxicity-pesticides, bio pesticides/biocontrol	7		
			Increase of pesticides use	3			Legislation to facilitate purchase of planting material from GRDB	5		
			Legislation for clean planting materials	1						
2	Rice_Integrated Pest Management (IPM)		Change of mind-set about spraying of synthetic pesticides	8	8.0		Enforcement of regulations on synthetic pesticides sell and use	5	5.0	-3.0
			Weak regulation and monitoring of synthetic pesticides use	8			Reinforce of IPM strategies (biocontrol and biopesticides)	5		
3	Plantain_Improved land drainage (excavation/drains) R3		Low awareness of financial access	9	6.3		Potential benefits in terms of productivity	5	6.0	1.8
			Time consuming	7			Training on types of excavations (e.g. wells) and use the slope in favour (contour lines)	5		
			Climate Variability (limit activities)	8			Demonstration plots to prove benefits on community food security	5		
			Poor Land use planning	1			Continuous improving of Climate Services	5		
							Multi-criteria evaluation for land use planning	10		
							Provision of equipment to farmers groups	6		
4	Plantain_Improved irrigation systems (e.g. sprinkler) R3		Low awareness of financial access	9	5.0		Demonstrate potential benefits in terms of productivity	5	6.0	1.0
			Conventional thinking/behaviour in agricultural production	2			Training on types of irrigation systems (use and maintaining)	5		
			Water availability	4			Water Harvesting systems	8		
5	Cassava_Improved drainage system R3		Low awareness of financial access	9	5.5		Potential benefits in terms of productivity	5	7.0	1.5
			Conventional thinking/model in agricultural production	8			Training on types of excavations (wells), use the slope in favour	5		
			Climate variability	4			Water Harvesting	8		
			Poor Land Use planning	1			Multi-criteria evaluation for land use planning, provision of equipment to farmers group	10		
6	Cassava_Water effcient irrigation (e.g. sprinkler) R3		Low awareness and access to financial and technical possibilities	9	9.0		Demonstrate potential benefits in terms of productivity	5	5.0	-2.0
							Training on alternative types of irrigation systems and water sources (wells), contourlines and use of the slope in favour for irrigation	5		
							Increase financing opportunities and credit facilities	5		
7	Sweet Potato_Improved drainage systems R3		Limited financing	9	5.5		Demonstrating potential increases in yield	5	7.0	1.5
			Conventional thinking/model in agricultural production	8			Stablished farmers groups	5		
			Water availability	4			Water Harvesting systems	8		
			Poor Land Use planning	1			Multi-criteria evaluation for land use planning	10		
8	Sweet Potato_Use of climate resilient varieties R3		Limited knowledge and development of local varieties, despite they exist	7	5.7		Use current and upcoming projects that involve tissues culture and varieties development	7	6.5	1.8
			Availability of short-cycle varieties	2			Possibility to strengthen food security and increase productivity	8		
			No plant breeding programme at national level e.g. NAREI	8			Explore local or foreign varieties availability through NAREI	8		
							Conventional plant breeding to select local varieties with adaptability potential	3		
9	Coconut_Improved land drainage systems R3		Access to financing opportunities	10	5.5		Promotion and growing attention to sustainable farming systems	6	7.6	3.1
			Resistance to change conventional agriculture practices	7			Scientific evidence, make visible results/impacts from past jobs	7		
			Water availability	4			Water Harvesting systems	8		
			Poor land use planning	1			Multi-criteria evaluation for land use planning	10		
							Provision of equipment to farmers group	7		
10	Coconut_Diversification of coconut varieties R3		It requires time to new varieties to be productive	10	7.8		Market demand due to increase in consumption	5	5.4	-1.4
			Availability of varieties	4			Set up nurseries	5		
			Cross breeding	9			Farmer fields schools and demo plots	5		
			Fragmented coconut industry	8			Zoning to avoid cross breeding	8		
							Set up national board to oversee the coconut industry	4		
11	Pineapple_Water reservoir/ponds and irrigation+pumps R3		Limited knowledge around the practice	4	6.7		Activities/spaces to demonstrate increase in production	2	6.3	0.6
			Difficult to adopt and maintain the practice	10			Economic mechanism to facilitate acquisition or rental of equipment to farmers groups	6		
			Availability and access to water during dry season	6			Highlight benefits of Efficient Water Management	8		
							Complementarity with water harvesting techniques	9		
12	Pineapple_Use of climate resilient varieties R3		Acceptance, access and availability of new varieties	9	5.0		Successful cases of happy farmers currently adopting varieties with special traits	5	5.0	0.0
			There is not plant breeding programmes	1			Strengthen plant breeding programmes to select varieties that are adaptable or with beneficial traits	5		

● Socio-cultural ● Environmental ● Economic ● Political/institutional ● Educational/information ● Multidimensional

Table 9. Barriers and Opportunities by CSA practice in Region 9.

REGION 9

	Crop_CSA Practice_Region	Type	Barriers 0= Very easy to overcome / 10= Very difficult to overcome	Score	Aver.	Type	Opportunities 0= Very difficult to attain / 10 = Very easy to attain	Score	Aver.	Total score
13	Rice_Improved drainage system_R9		No institutional policy available to be implemented	9	6.3		Policy framework can be discussed and eventually implemented	4	4.8	0.6
			Meet EPA and NDIA standards	5			Time constraints to be overcome for approval	2		
			Decentralized service	5			More local offices for access each region	3		
			High cost	6			Seek funds from NGOs and other organizations	7		
			Topography of the land	9			Possibility to explore and seize organic agriculture benefits	6		
			Required extension services	5			Use of arable land	5		
			Enough market information	5			Complement with water harvesting systems	6		
			It is not a staple for the region	6			More access to extension services	5		
							Education through Farmers Field Schools	2		
							Alternative food item to bridge gap with traditional food crops	8		
14	Rice_Adusted time of planting_R9		No institutional policy available to be implemented	8	6.3		Agencies (e.g. hydromet, GRDB, NAREI) should inform policies around practices implementation	8	5.7	0.4
			Low yield quality	5			Quality improves along the time	5		
			Limited extension services and climate change information	5			Sinergy with water harvesting systems	6		
			Lack of market Information	5			Facilitate/more access to extension services	5		
			Lack of infrastructure/irrigation availability	9			Education through Farmers Field Schools	2		
			Not a staple for the region	6			Alternative food item to bridge gap with traditional food items	8		
							Indigenous knowledge	6		
15	Plantain_Intercropping e.g. cassava, pumpkin, watermelon_R9		Market is not well developed	5	5.5		NGMC to create linkage access to markets	5	4.6	0.1
			Access to disease free planting material	8			Micro-propagation of disease-free planting material	4		
			Not commercial plantations	4			Potential market for value added products	6		
			Lack of knowledge on crop opportunities for intercropping, and custom to grow only one crop per planting season	5			More farmers training opportunities	2		
							Availability of technologies to complement practice adoption	6		
16	Plantain_Improved drainage system_R9		No institutional policy available to promote implementation	5	5.0		Protocols and credits creation to mitigate land degradation	5	4.0	1.0
							More farmers training	2		
							Availability of technologies to complement practice adoption	5		
17	Peanuts_Crop rotation with read bean_R9		Agricultural policies usually doesn't address this type of practices	8	6.9		Crop rotation should be included in polices and programs to avoid land degradation and pest outbreaks, promoted by MoA	3	5.0	0.1
			Perceived high cost depending of crop rotation	5			Technical assistance from public institutions	5		
			Access and application of R&D and market	8			Seek assistance from NGMC for market linkage	5		
			Cheap importation of peanuts	8			Lobby government and ensure coordinated production	3		
			Access to farming areas	7			Possibility to incentivise production	5		
			Storage facilities limitation	7			Reduction in pest and diseases incidence	6		
			Overdependence on weather (wet season) for cultivation	5			Reduce slash and burn systems	5		
							Availability of technologies (e.g. irrigation)	5		
							Training on packaging and processing NGMC	8		
							Opportunities for market research skills training	8		
18	Peanuts_IPM: Keep areas of natural habitat_R9		Limited farm land size	9	6.7		Lobby government and ensure coordinated production	3	6.6	0.9
			Lack of application of technologies	8			Possibility to incentivise production	5		
			Cheap importation of peanuts	8			Availability of technology	5		
			Access to farming areas	7			Training on packaging on processing NGMC	8		
			Overdependence on weather (wet season) for cultivation	5			Opportunities for market research skills training	8		
			Lack of skills for value addition	5			Preserving natural habitat	8		
			Presence of more predators (animals)	5			Opportunities for Carbon credit projects	8		
							Preserving wildlife	8		
19	Cassava_Crop rotation_R9		No policy that directly mention crop rotation	5	6.8		Expertise accumulated by farmers and communities	10	5.6	-0.2
			Lack of knowledge/information of crop options for rotation	5			Complement with rainwater harvesting and drainage techniques	5		
			Limited drainage and irrigation systems	9			Savannah planting options	5		
			Traditional/conventional way of planting	8			Availability of technology	6		
							Availability of spaces/events for more farmers training	2		
20	Cassava_Improved drainage system_R9		Traditional/cultural way of planting and low implementation of sustainable technologies	8	8.0		Savannah planting options	5	4.5	-0.5
							Water harvesting opportunity	5		
							More training options for farmers	2		
							Availability of technology	6		
21	Cashew nut_Water harvesting_R9		No policy related to water harvesting	2	5.5		NDIA, village plan and GWI should mention this within the policies	8	5.2	1.7
			Perceived high implementation cost	5			Seek funding from different organizations NGOs, banks, NDIA, GWI	7		
			Commercial/formal cultivation systems is not a custom	7			Agriculture as an economic opportunity	3		
			Trees planted are widespread	8			Varied marketing opportunities	3		
							Educational opportunities	5		
							Infrastructure in development	5		
22	Cashew nut_Tree management (pruning)_R9		Crop no promoted in policy for the region	10	8.0		Promote trees and orchids planting through local/national policies	2	5.0	1.0
			Lack of commercial/formal cultivation systems	7			Expansion of cashew nut production	3		
			Basic processing techniques	7			Varied marketing opportunities	3		
			Dependency on one rainy season	8			Education and training opportunities for farmers and technicians	5		
							Infrastructure in development	5		
							Complementary practices to increase water availability in dry season	7		
							More projects on Climate resilient and technologies for water catchment and conservation	7		
							Increase in biodiversity and asociated benefits	8		

● Socio-cultural ● Environmental ● Economic ● Political/institutional ● Educational/information ● Multidimensional

CSA investment portfolios, weighting prioritization criteria

An essential step for setting the scope of investment portfolios is the definition of the importance that stakeholders give to each CSA-PF criterion contextualized to the local food system realities. With this in mind, during the regional workshops, participants evaluated and weighed the different prioritization criteria.

In Region 3, participants concluded that the three criteria should have an equitable weight in the analysis (33%) (see Figure 15). However, within the "CSA Indicators" criterion, *adaptation* is the most important approach for them (58%), followed by *food and nutritional security* (35%), while the *mitigation* pillar – for the moment – is perceived as not essential for their agricultural production. On the other hand, in Region 9, the actors considered that the effects of practices/portfolios on CSA pillars are preponderant for their production systems – assigning 50%. Within this criterion, in contrast to Region 3, *food and nutritional security* is a priority (45%), followed by the development of *resilience/adaptation capacity* (35%) and to a lesser extent – but even higher than in Region 3 – *mitigation* with 20%. Regarding the remaining criteria, the stakeholders considered that addressing the barriers and opportunities for implementing CSA practices is relatively more relevant to their context than the economic implications alone, i.e. the economic costs and benefits of adopting the CSA practices.

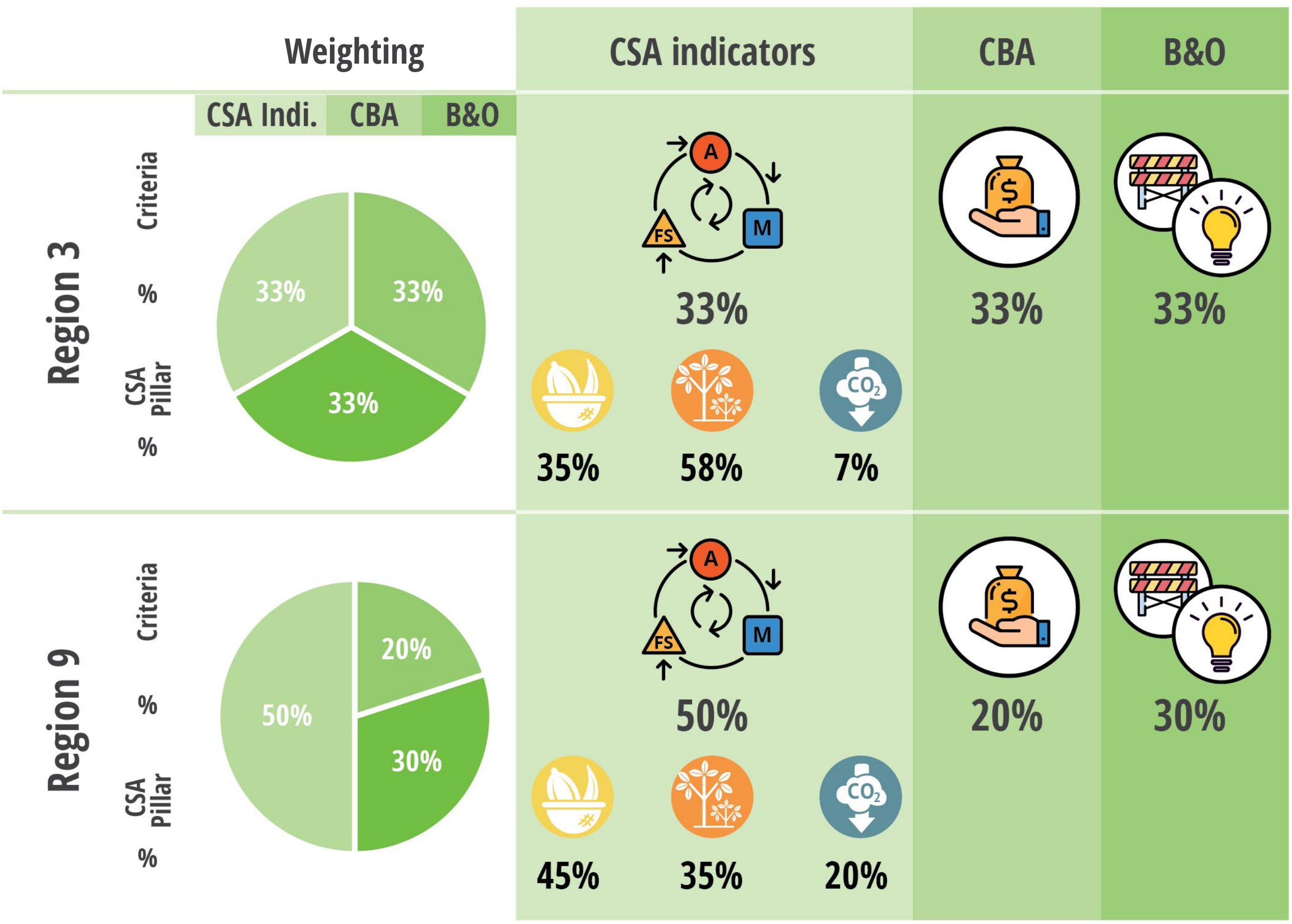


Figure 15. Weighting of prioritization criteria and CSA pillars by local stakeholders.

It is important to mention that the perception of climate-change-related concepts and their interpretation precise-tuning for their context is dependent of diverse factors that define social groups, inter alia, education level, income level, farm size and location, gender, access to agricultural extension services, credits and climate information, etc. (Gadédjisso-Tossou, 2015; Khatri-Chhetri et al., 2017). For this reason, the CSA-PF Excel tool used during the workshops to configure the CSA portfolios is able to capture the weighting of the prioritization criteria given by participants. This means that any modification in these values – even in the future, after the implementation of the CSA-PF process – immediately reflects the changes that it implies in the characteristics and performance of selected CSA practices and portfolios[16].

CSA investment portfolios designed by region

In an ideal scenario, a first level of configuration for a CSA investment portfolio can be framed based on top CSA practices prioritized across the production systems (crops) in each region. Furthermore, all information collected during the participatory process in relation to the different prioritization criteria allowed to weigh all single criterion based on participants' inputs (previous section) in order to create a dynamic ranking[17] of best-bet CSA practices as presented in Table 10.

Table 10. Ranked list of CSA practices based on general weighting by region (negative scores does not mean weak performance).

	Practices Ranking (Region 3)	General Weighted Score	Final Ranking
1	Sweet Potato_Improved drainage systems R3	4.7	1
2	Sweet Potato_Use of climate resilient varieties R3	4.2	2
3	Pineapple_Water reservoir/ponds and irrigation+pumps R3	3.4	3
4	Plantain_Improved irrigation systems (e.g. sprinkler) R3	2.9	4
5	Coconut_Improved land drainage systems R3	2.6	5
6	Plantain_Improved land drainage (excavation/drains) R3	2.6	6
7	Cassava_Improved drainage system R3	2.4	7
8	Pineapple_Use of climate resilient varieties R3	2.2	8
9	Cassava_Water effcient irrigation (e.g. sprinkler) R3	1.0	9
10	Coconut_Diversification of coconut varieties R3	-0.5	10
11	Rice_Produce and use of clean seeds R3	-0.7	11
12	Rice_Integrated Pest Management (IPM) monitoring R3	-1.6	12

	Practices Ranking (Region 9)	General Weighted Score	Final Ranking
1	Peanuts_Crop rotation with read bean_R9	5.4	1
2	Plantain_Intercropping e.g. cassava, pumpkin, watermelon_R9	4.6	2
3	Cashew nut_Water harvesting_R9	4.5	3
4	Cashew nut_Tree management (pruning)_R9	4.4	4
5	Peanuts_IPM: Keep areas of natural habitat_R9	3.9	5
6	Plantain_Improved drainage system_R9	3.6	6
7	Rice_Adusted time of planting_R9	2.9	7
8	Rice_Improved drainage system_R9	2.0	8
9	Cassava_Improved drainage system_R9	1.9	9
10	Cassava_Crop rotation_R9	1.2	10

This ranking serves as a guide for stakeholders to identify which practices have a better overall performance through quantifying in each indicator of each criterion assessed, the total score obtained[18] giving a complete picture of the economic costs and benefits, the advantages in terms of food security, adaptation, and mitigation, and of course the barriers and opportunities. This also enables a much simpler way to compare global portfolio's performance when different combinations of practices are selected or even when stakeholders wanted to add new practices to the portfolio(s) for future exercises.

The following figures show the detailed result values by indicator and criterion, as well as the bars and pie graphs that summarize the total scores for all practices in the general portfolio(s), indicating the average of: Cost/benefit ratio, Internal Rate of Return, Payback Period; CSA indicators evaluation; Barriers difficulty; and Opportunities attainability. Along with the sum of the Practices Cost, Total Net Income, Net Present Value, amount of Barriers; and amount of Opportunities. Cells highlighted in dark and light gray represent favorable and less favorable values within each indicator, respectively.

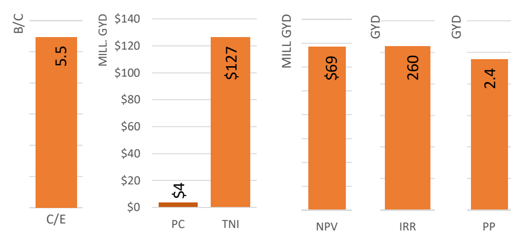
[16] The CSA portfolios are the main output of the PF process. Their objective is to facilitate decision-making in the transition to a sustainable food system. CSA portfolios are a context-specific selection of priority agricultural practices that address socio-environmental issues, seek to maximize investment yield and minimize income risk, while seizing synergies and avoiding trade-offs.

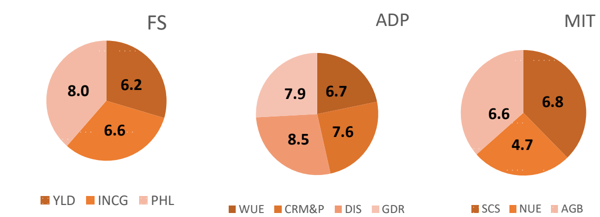
[17] Dynamic ranking refers to the fact that there is no definitive or static ranking of CSA practices, because due to the complex nature of the prioritization process, participants can modify the different values, parameters, and weights at any time to suit their needs and to best adapt to the contextual reality of their territory.

[18] The performance of the portfolio(s) of practices is calculated on the one hand through an average: B/C; IRR; PP, All CSA indicators; B. difficulty; and O. attainability. And, on the other hand, through a sum: PC; TNI; NPV; amount of B.; and amount of O.

#	Indicator / Abbreviation / Practices	Benefit/Cost Ratio	Practice Cost	Total Net Income	Net Present Value	Internal Rate of Return	Payback Period
	Abbreviation	B/C	PC	TNI	NPV	IRR	PP
	Practices	-	GYD	GYD	GYD	%	Years
1	Cassava_Improved drainage system R3	4.2	84,000	6,065,590	3,320,237	280	1.4
2	Cassava_Water effcient irrigation (e.g. sprinkler) R3	4.2	300,000	6,773,590	3,678,872	222	1.3
3	Coconut_Improved land drainage systems R3	6.9	72,000	3,016,200	1,252,838	50	4.3
4	Coconut_Diversification of coconut varieties R3	2.9	1,100,000	3,001,975	1,201,158	42	4.1
5	Pineapple_Water reservoir/ponds and irrigation+pumps R3	12.2	72,000	23,000,130	12,561,015	275	2.6
6	Pineapple_Use of climate resilient varieties R3	10.1	505,010	22,567,120	12,309,942	263	2.6
7	Plantain_Improved land drainage (excavation/drains) R3	4.4	900,000	12,859,800	7,056,193	303	1.8
8	Plantain_Improved irrigation systems (e.g. sprinkler) R3	5.1	510,000	14,167,800	7,792,987	380	1.6
9	Rice_Produce and use of clean seeds R3	1.0	0	1,055,500	540,051	91	2.9
10	Rice_Integrated Pest Management (IPM) monitoring R3	1.9	0	1,303,500	662,817	98	2.7
11	Sweet Potato_Improved drainage systems R3	6.8	66,000	17,716,556	9,835,121	544	1.6
12	Sweet Potato_Use of climate resilient varieties R3	6.1	0	14,992,076	8,353,464	566	1.8
	Performance	**5.5**	**$3,609,010**	**$126,519,837**	**$68,564,695**	**260**	**2.4**

#	Food Security			Adaptation				Mitigation			Barriers		Opportunities	
	YLD	INCG	PHL	WUE	CRM&P	DIS	GDR	SCS	NUE	AGB	Amount	Difficulty	Amount	Attainability
	Kg/acre	re/ season	Kg/acre	L/produ	Capacity to	# Ag./econ	Participati	% or Kg/Ac	Change in	Ton/Season/Acre	#	-10 to 10	#	-10 to 10
1	8.5	8.0	8.5	8.5	3.0	8.0	7.0	4.0	5.0	4.0	4	6	4	7
2	5.5	9.0	8.5	9.0	8.5	8.0	7.0	5.0	4.0	4.0	1	9	3	5
3	9.0	7.0	5.0	7.0	5	10.0	7.0	4.5	6.0	10.0	4	6	5	8
4	6.5	3.5	9.0	3.5	9	10.0	8.0	6.5	6.0	7.5	4	8	5	5
5	6.0	8.0	10.0	8.0	10	10.0	10.0	8.0	8.0	10.0	3	7	4	6
6	6.0	7.0	7.0	7.0	7	8.0	7.0	6.0	7.0	9.0	2	5	2	5
7	2.0	7.0	9.5	7.0	10	10.0	10.0	8.0	N/A	7.0	4	6	6	6
8	4.0	5.0	8.0	5	8	10.0	9.0	8.0	N/A	6.0	3	5	3	6
9	6.0	4.0	8.0	4	8	6.0	8.0	6.0	2.0	1.0	6	5	5	6
10	4.5	3.0	3.0	3	3	3.0	2.0	8.0	N/A	1.0	2	8	2	5
11	10.0	10.0	10.0	10	10	9.5	10.0	9.0	2.0	10.0	4	6	4	7
12	6.0	8.0	10.0	8	10	9.0	10.0	9.0	2.0	10.0	3	6	4	7
Performance	**6.2**	**6.6**	**8.0**	**6.7**	**7.6**	**8.5**	**7.9**	**6.8**	**4.7**	**6.6**	**40**	**6.3**	**47**	**6.1**





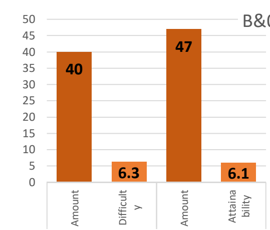


Figure 16. General CSA investment portfolio. Region 3.

Indicator	Benefit/Cost Ratio	Practice Cost	Total Net Income	Net Present Value	Internal Rate of Return	Payback Period
Abbreviation	B/C	PC	TNI	NPV	IRR	PP
Practices	-	GYD	GYD	GYD	%	Years
Cassava_Crop rotation_R9	0.9	1,162,500	-132,394	-214,228	0	0.0
Cassava_Improved drainage system_R9	1.6	162,900	1,032,090	432,048	39	3.4
Peanuts_Crop rotation with read bean_R9	3.1	60,000	2,956,700	1,589,515	178	1.2
Peanuts_IPM: Keep areas of natural habitat_R9	2.0	550,000	1,982,700	1,011,670	101	2.8
Plantain_Intercropping e.g. cassava, pumpkin, watermelon_R9	3.7	328,400	2,313,940	1,260,256	202	1.5
Plantain_Improved drainage system_R9	3.1	500,000	2,169,250	966,834	46	3.8
Rice_Improved drainage system_R9	1.0	169,200	-28,900	-203,745	-1	0.0
Rice_Adusted time of planting_R9	0.9	0	-129,700	-177,266	-11	0.0
Cashew nut_Water harvesting_R9	0.0	0	0	0	0	0.0
Cashew nut_Tree management (pruning)_R9	0.0	0	0	0	0	0.0
	nd	nd	nd	nd	nd	nd
	nd	nd	nd	nd	nd	nd
Performance	1.6	$2,933,000	$10,163,686	$4,665,084	55	1.3

Indicator	Food Security			Adaptation				Mitigation			Barriers		Opportunities	
Abbreviation	YLD	INCG	PHL	WUE	CRM&P	DIS	GDR	SCS	NUE	AGB	Amount	Difficulty	Amount	Attainability
Practices	Kg/acre	e/ seasor	Kg/acre	L/produ	Capacity t	# Ag./econ	Participat	% or Kg/A	Change ir	Ton/Seas	#	-10 to 10	#	-10 to 10
Cassava_Crop rotation_R9	3.5	3.5	N/A	6.5	7.0	8.0	6.0	7.0	6.5	7.0	4	7	5	6
Cassava_Improved drainage system_R9	7.5	7.5	N/A	7.5	N/A	3.0	4.5	5.0	3.0	2.0	1	8	4	5
Peanuts_Crop rotation with read bean_R9	9.0	9.0	8.0	9.0	8.0	8.0	9.0	8.0	8.0	8.0	7	7	10	5
Peanuts_IPM: Keep areas of natural habitat_R9	8.0	8.0	9.0	8.0	9.0	7.0	9.0	8.0	7.0	8.0	7	7	8	7
Plantain_Intercropping e.g. cassava, pumpkin, watermelon_R9	7.0	8.0	N/A	8.0	N/A	9.0	7.0	9.0	8.0	9.0	4	6	5	5
Plantain_Improved drainage system_R9	8.0	8.0	N/A	8.0	N/A	8.0	5.0	5.0	9.0	5.0	1	5	3	4
Rice_Improved drainage system_R9	9	N/A	7	N/A	7	9.0	7	N/A	N/A	7	8	6	10	5
Rice_Adusted time of planting_R9	7.0	6.0	8	6	8	9.0	N/A	N/A	N/A	6	6	6	7	6
Cashew nut_Water harvesting_R9	7.0	7.0	8.0	7	8	9	8.0	8.0	9.0	9	4	6	6	5
Cashew nut_Tree management (pruning)_R9	8.0	8.0	9.0	8	9	9	8.0	9.0	8.0	9.0	4	8	8	5
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0		0	
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0		0	
Performance	7.4	7.2	8.2	7.6	8.0	7.9	7.1	7.4	7.3	7.0	46	6.5	66	5.1

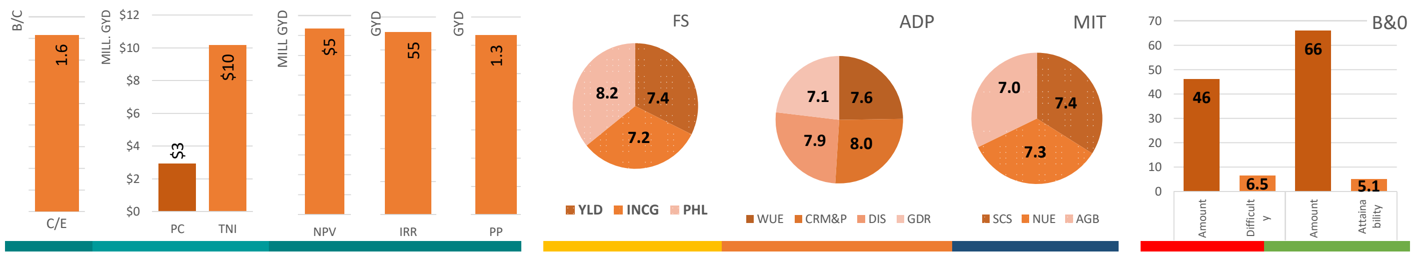


Figure 17. General CSA investment portfolio. Region 9.

Exploring alternative CSA investment portfolios

Alternatives Region 3

Objective setting:

To understand socio-economic and environmental benefits of implementing CSA practices focused on both drought- and flood-prone areas of rice, plantain, and coconut production for small- to medium-scale farmers, seeking to strength research and funding in Essequibo Islands-West Demerara, Guyana.

Crops selected to compare portfolios:

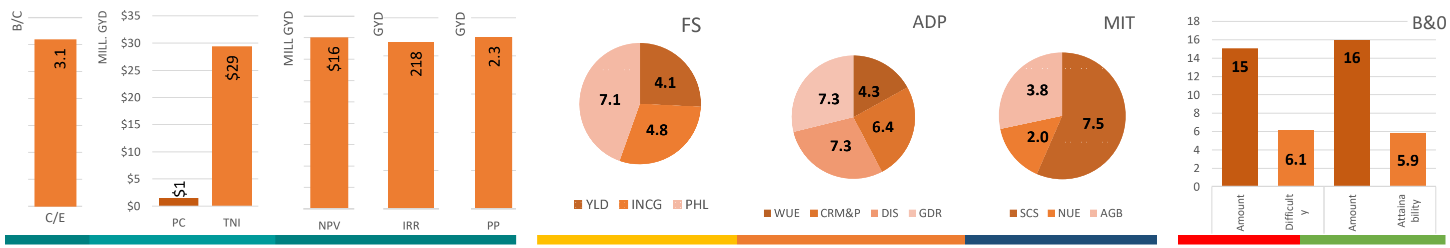
Rice + Plantain (portfolio A) vs. Rice + Coconut (portfolio B)

Portfolios results and visualization:

Portfolio A

Practices (Indicator / Abbreviation)	Benefit/Cost Ratio	Practice Cost	Total Net Income	Net Present Value	Internal Rate of Return	Payback Period
Abbreviation	B/C	PC	TNI	NPV	IRR	PP
	-	GYD	GYD	GYD	%	Years
1 Rice_Produce and use of clean seeds R3	1.0	0	1,055,500	540,051	91	2.9
2 Rice_Integrated Pest Management (IPM) monitoring R3	1.9	0	1,303,500	662,817	98	2.7
3 Plantain_Improved land drainage (excavation/drains) R3	4.4	900,000	12,859,800	7,056,193	303	1.8
4 Plantain_Improved irrigation systems (e.g. sprinkler) R3	5.1	510,000	14,167,800	7,792,987	380	1.6
Performance	**3.1**	**$1,410,000**	**$29,386,600**	**$16,052,048**	**218**	**2.3**

Practices	Food Security			Adaptation				Mitigation			Barriers		Opportunities	
	YLD	INCG	PHL	WUE	CRM&P	DIS	GDR	SCS	NUE	AGB	Amount	Difficulty	Amount	Attainability
	Kg/acre	re/ season	Kg/acre	L/produc	Capacity tc	# Ag./econ	Participati	% or Kg/Ac	Change in	Ton/Season/Acre	#	-10 to 10	#	-10 to 10
1	6.0	4.0	8.0	2.0	5.0	6.0	8.0	6.0	2.0	1.0	6	5	5	6
2	4.5	3.0	3.0	3.0	3.0	3.0	2.0	8.0	N/A	1.0	2	8	2	5
3	2.0	7.0	9.5	7.0	10	10.0	10.0	8.0	N/A	7.0	4	6	6	6
4	4.0	5.0	8.0	5.0	8	10.0	9.0	8.0	N/A	6.0	3	5	3	6
Performance	**4.1**	**4.8**	**7.1**	**4.3**	**6.4**	**7.3**	**7.3**	**7.5**	**2.0**	**3.8**	**15**	**6.1**	**16**	**5.9**



Portfolio B

Practices (Indicator / Abbreviation)	Benefit/Cost Ratio	Gross Income	Gross costs	Net Present Value	Externality: Biodiversity	Externality: Carbon capture
Abbreviation	B/C	PC	TNI	NPV	IRR	PP
	-	GYD	GYD	GYD	%	Years
1 Rice_Produce and use of clean seeds R3	1.0	0.0	1055500.0	540051.0	9100%	2.9
2 Rice_Integrated Pest Management (IPM) monitoring R3	1.9	0.0	1303500.0	662817.0	9800%	2.7
3 Coconut_Improved land drainage systems R3	6.9	72000.0	3016200.0	1252838.0	5000%	4.3
4 Coconut_Diversification of coconut varieties R3	2.9	1100000.0	3001975.0	1201158.0	4200%	4.1
Performance	**3.2**	**$1,172,000**	**$8,377,175**	**$914,216**	**7025%**	**4**

Practices	Food Security			Adaptation				Mitigation			Barriers		Opportunities	
	YLD	INCG	PHL	WUE	CRM&P	DIS	GDR	SCS	NUE	AGB	Amount	Difficulty	Amount	Attainability
	Kg/acre	re/ season	Kg/acre	L/produc	Capacity tc	# Ag./econ	Participati	% or Kg/Ac	Change in	Ton/Season/Acre	#	-10 to 10	#	-10 to 10
1	6.0	4.0	8.0	2.0	5.0	6.0	8.0	6.0	2.0	1.0	6	5	5	6
2	4.5	3.0	3.0	4.0	5.0	3.0	2.0	8.0	N/A	1.0	2	8	2	5
3	9.0	7.0	5.0	9.0	9.0	10.0	7.0	4.5	6.0	10.0	4	6	5	8
4	6.5	3.5	9.0	2.0	8.5	10.0	8.0	6.5	6.0	7.5	4	8	5	5
Performance	**6.5**	**4.4**	**6.3**	**4.3**	**6.9**	**7.3**	**6.3**	**6.3**	**4.7**	**4.9**	**16**	**6.6**	**17.0**	**6.1**

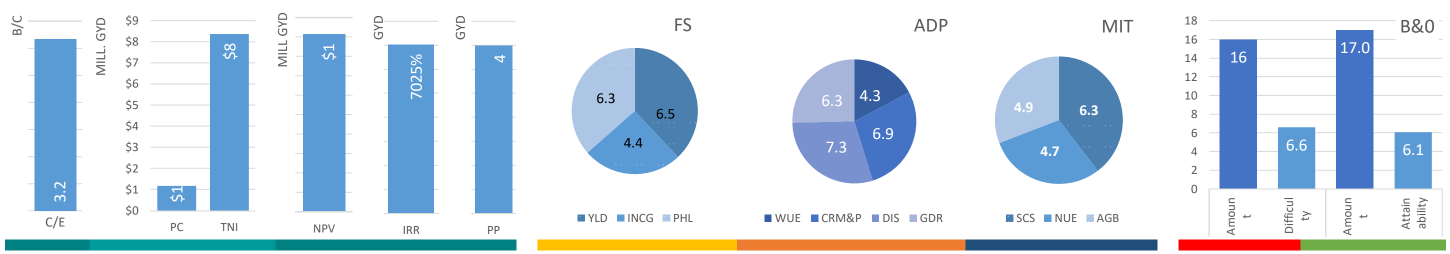


Figure 18. CSA portfolios results and visualization. Region 3.

Trade-offs and synergies (portfolios comparison)

Figure 19. CSA Portfolios comparison. Region 3.

Economic: For this criterion, Portfolio A (Rice + Plantain) shows greater financial indicators, the Cost/benefit ratio is equivalent, and the total cost of the practices within Portfolio B (Rice + coconut) is lower by GYD 238,000. This is because the practices in coconut have a higher cost and rice does not influence this indicator in both portfolios – as their implementation costs under the assumptions of this study are considered GYD 0, being a comparative advantage of these practices. The Net Present Value generated by Portfolio A is 3.5 times greater than Portfolio B, which means that this set of practices represents an attractive investment alternative, especially because in average the IRR is considerably high (148%). Portfolio A also has the potential to recover the investment in 2.3 years, that is, 1.3 years earlier than Portfolio B, which is understandable, because in the case of coconut – being a perennial crop – whose vegetative and productive phases are relatively longer than in plantain. It is worth noting that, in this case, as the diversification strategy in coconut involves the use of dwarf varieties, crop harvesting can start after 3–5 years and become fully productive around year 6, implying shorter payback periods compared to tall varieties (Pilgrim, 2011; CARDI, 2019). Crop cash flows can even be improved by intercropping with annual crops.

CSA indicators: In terms of *Food and nutritional security,* both portfolios perform similarly; however, average score in Portfolio B is slightly greater, mainly because a greater benefit in yield is perceived. Nevertheless, TNI indicators demonstrate that considering plantain and coconut only, the income is higher for the former. As for *Adaptation benefits*, participants highlighted that even though the total average score under this CSA pillar is the same, individual indicators reveal that Portfolio A could have greater potential to positively impact the gender indicator (GNR), i.e. progress in women's participation in decision-making, income distribution, free time, etc. as a result of practices implementation, but also due to the type of crop and farming systems per se. While Portfolio B can perform slightly better in terms of perceived benefits for the CRM&P indicator (capacity to manage, avoid and/or withstand climate risks and hazards). Finally, mitigation benefits tend to be higher in coconut due to a greater carbon capture in above-ground biomass, and nutrient-use efficiency. Furthermore, plantain is observed as a good contributor to the Soil Carbon Stock (SCS) due to the constant generation of organic matter that this crop can provide to the soil.

- **Barriers and opportunities:** Bearing in mind that the economic criterion is dominated by Portfolio A, and CSA indicators perform better in Portfolio B, the identified opportunities and barriers to adoption are not quite contrasting in number and magnitude for both portfolios. The amount of opportunities in both cases is quite similar, indicating that, for every single barrier, there exists one or more opportunities to be seized. However, the perceived difficulty to overcome these barriers is perceived to be slightly greater than the ease with which opportunities can be attained. In this regard, as discussed in the B&O section, rice and coconut experience considerable constraints across the proposed dimensions. Nevertheless, these proved to be surmountable, when identified opportunities – most of them associated with education/information and political/institutional dimensions, and to a lesser extent with the environment – become part of a joint collaboration program involving farmers and the public and private sectors around the work being advanced in the field of climate change in the agricultural sector.

- **Total account:** from the different criteria evaluated, the total count shows that both Portfolios A and B are comparable. Therefore, more differences can be explored in detail going through the specific indicators and results. In this case, the criteria were weighed equally, but it is also possible for stakeholders to readjust the weighting percentage (%) of individual indicators or even criterion, aiming to reveal and explore additional synergies and trade-offs between practices and portfolios. This in tune with the objectives of the group portfolios.

Alternatives Region 9

Objective setting:

Identify the combination of practices that contribute to a sustainable increase in productivity, overall food security and climate change adaptation, particularly to flooding and extreme dry seasons, by increasing climate resilience awareness and farm/community activities diversification, while representing viable and profitable options for small-scale farmers in the Upper Takutu-Upper Essequibo region, Guyana.

Crops selected to compare portfolios:

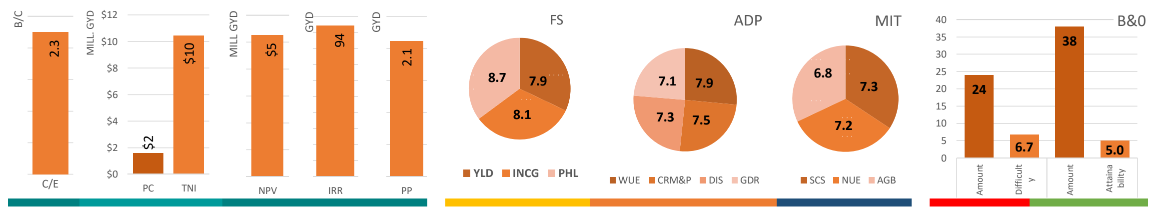
Cassava + Cashew nut + Plantain + Peanuts (Portfolio A) vs. Rice + Plantain + Peanut (Portfolio B).

Portfolios results and visualization:

Portfolio A

	Indicator	Benefit/Cost Ratio	Practice Cost	Total Net Income	Net Present Value	Internal Rate of Return	Payback Period
	Abbreviation	B/C	PC	TNI	NPV	IRR	PP
	Practices	-	GYD	GYD	GYD	%	Years
1	Cassava_Improved drainage system_R9	1.6	162,900	1,032,090	432,048	39	3.4
2	Cashew nut_Tree management (pruning)_R9	0.0	0	0	0	0	0.0
3	Plantain_Intercropping e.g. cassava, pumpkin, watermelon_R9	3.7	328,400	2,313,940	1,260,256	202	1.5
4	Plantain_Improved drainage system_R9	3.1	500,000	2,169,250	966,834	46	3.8
5	Peanuts_Crop rotation with read bean_R9	3.1	60,000	2,956,700	1,589,515	178	1.2
6	Peanuts_IPM: Keep areas of natural habitat_R9	2.0	550,000	1,982,700	1,011,670	101	2.8
	Performance	2.3	$1,601,300	$10,454,680	$5,260,323	94	2.1

	Food Security			Adaptation				Mitigation			Barriers		Opportunities	
	YLD	INCG	PHL	WUE	CRM&P	DIS	GDR	SCS	NUE	AGB	Amount	Difficulty	Amount	Attainability
	Kg/acre	e/ seasoı	Kg/acre	L/produ	Capacity t	# Ag./econ	Participat	% or Kg/A	Change ir	Ton/Seas	#	-10 to 10	#	-10 to 10
1	7.5	7.5	N/A	6.5	4.0	3.0	4.5	5.0	3.0	2.0	1	8	4	5
2	8.0	8.0	9.0	8.0	9.0	9.0	8.0	9.0	8.0	9.0	4	8	8	5
3	7.0	8.0	N/A	8.0	N/A	9.0	7.0	9.0	8.0	9.0	4	6	5	5
4	8.0	8.0	N/A	8.0	N/A	8.0	5.0	5.0	9.0	5.0	1	5	3	4
5	9.0	9.0	8.0	9.0	8.0	8.0	9.0	8.0	8.0	8.0	7	7	10	5
6	8.0	8.0	9.0	8.0	9.0	7.0	9.0	8.0	7.0	8.0	7	7	8	7
Performance	7.9	8.1	8.7	7.9	7.5	7.3	7.1	7.3	7.2	6.8	24	6.7	38	5.0



Portfolio B

	Indicator	Benefit/ Cost Ratio	Practice Cost	Total Net Income	Net Present Value	Internal Rate of Return	Payback Period
	Abbreviation	B/C	PC	TNI	NPV	IRR	PP
	Practices	-	GYD	GYD	GYD	%	Years
1	Plantain_Improved drainage system_R9	3.1	500000	2169250	966834	46	3.8
2	Plantain_Intercropping e.g. cassava, pumpkin, watermelon_R9	3.7	328400	2313940	1260256	202	1.5
3	Peanuts_Crop rotation with read bean_R9	3.1	60000	2956700	1589515	178	1.2
4	Peanuts_IPM: Keep areas of natural habitat_R9	2.0	550000	1982700	1011670	101	2.8
5	Rice_Adusted time of planting_R9	0.9	0	-129700	-177266	-11	0.0
		nd					
	Performance	2.6	$1,438,400	$9,292,890	$4,651,009	103	1.9

	Food Security			Adaptation				Mitigation			Barriers		Opportunities	
	YLD	INCG	PHL	WUE	CRM&P	DIS	GDR	SCS	NUE	AGB	Amount	Difficulty	Amount	Attainability
	Kg/acre	e/ seasoı	Kg/acre	L/produ	Capacity t	# Ag./econ	Participat	% or Kg/A	Change ir	Ton/Season/	#	-10 to 10	#	-10 to 10
1	8.0	8.0	N/A	9.0	8.0	8.0	5.0	5.0	9.0	5.0	1	5	3	4
2	7.0	8.0	N/A	8.0	8.0	9.0	7.0	9.0	8.0	9.0	4	6	5	5
3	9.0	9.0	8.0	5.0	9.0	8.0	9.0	8.0	8.0	8.0	7	7	10	5
4	8.0	8.0	9.0	5.0	8.0	7.0	9.0	8.0	7.0	8.0	7	7	8	7
5	7.0	6.0	8.0	9.0	N/A	9.0	N/A	N/A	N/A	6.0	6	6	7	6
Performance	7.8	7.8	8.3	7.2	8.3	8.2	7.5	7.5	8.0	7.2	25	6.1	33	5.2

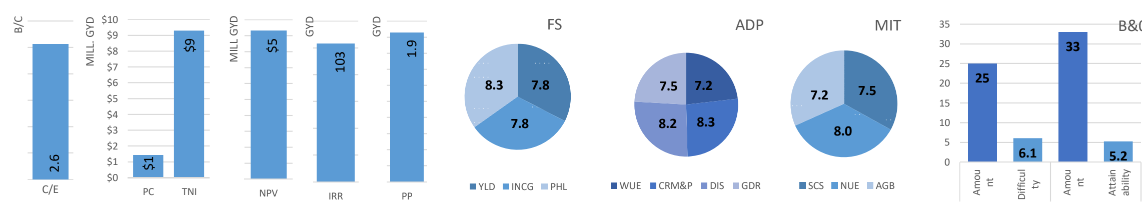
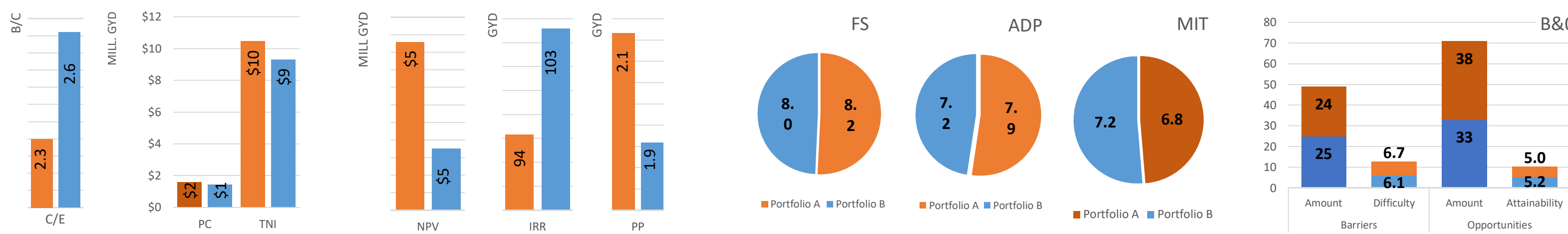


Figure 20. CSA portfolios results and visualization. Region 9.

Trade-offs and synergies (portfolios comparison).

	Benefit/Cost Ratio	Practice Cost	Total Net Income	Net Present Value	Internal Rate of Return	Payback Period	Criterion Weighting	Food Security	Adaptation	Mitigation	Criterion Weighting	Barriers		Opportunities		Criterion Weighting
	B/C	PC	TNI	NPV	IRR	PP		-	-	-		Amount	Difficulty	Amount	Attainability	
Portfolios	-	GYD	GYD	GYD	%	Years	33%	-	-	-	33%	#	0 to 10	#	0 to 10	33%
Portfolio A	2.3	$1,601,300	$10,454,680	$5,260,323	94	2.1		8.2	7.9	6.8		24	6.7	38	5.0	
Portfolio B	2.6	$1,438,400	$9,292,890	$4,651,009	103	1.9		8.0	7.2	7.2		25	6.1	33	5.2	
Difference between porfolios?	0.3	$162,900	$1,161,790	$609,314	9	0.3		0.2	0.7	0.4		1.0	0.6	5.0	0.2	
Best option?	B	B	A	A	B	B		A	A	B		A	B	A	B	



TOTAL COUNT	
Portfolio A	6
Portfolio B	7

Figure 21. CSA Portfolios comparison. Region 9.

Economic: For this criterion, Portfolio B (Rice + Plantain + Peanut) shows greater financial indicators, except for TNI and PNV, where the difference between portfolios is relatively low, i.e. GYD 1,161,790 and GYD 609,314, respectively. The Cost/benefit ratio is slightly higher in Portfolio B, indicating that the monetary gains generated by the selected practices is greater than the cost of implementing and maintaining them. This result is aligned with the Internal Rate of Return, in which the difference is only 9 percentage points higher in favour of Portfolio B. Total cost of the practices within Portfolio A (Cassava + Cashew nut + Plantain + Peanuts) is greater by GYD 162,400 which is attributed mainly to the cost of the selected practice in cassava, as practices in rice and cashew nut have no substantial value (GYD 0) under the assumptions of the analysis, and the costs for plantain and peanuts are the same, regardless the portfolio. Unlike Portfolio B, the crops selected in Portfolio A include a perennial crop (cashew nut), which in addition to the payback period of the other practices, imply that the PP extends slightly, i.e. 0.3 years. It is worth mentioning that participants also considered that the economic criterion should not be the strongest reason to rank and compare the practices and portfolios, assigning a weight of 20%. Despite rice is still being an emerging crop in Region 9 and there are yield gaps that can be filled, for instance, through adoption of CSA options, the practices evaluated in this crop for both portfolios are expected to deliver financial benefits to small- to medium-scale farmers.

CSA indicators: This is one of the key criterion identified by stakeholders in the process, representing 50% of the total weight. The practices selected performed greater in the *Food and Nutritional security* pillar compared to *Adaptation* and *Mitigation* components. The qualitative assessment of the indicators under this pillar averaged 8.0 and 8.2 for portfolios B and A, respectively. In contrast, Adaptation indicators (CRM&P, DIS, and GDR) were greater for Portfolio B. It is worth noting that, for the GDR indicator, practices related to irrigation and drainage systems seem not to be strong options compared to practices related to diversification (e.g. intercropping, crop rotation) and conservation strategies (keep areas of natural habitat). Regarding Mitigation potential, Portfolio B was higher in all indicators, though global average scores in both portfolios are good, meaning that mitigation opportunities in this kind of production system and practices can be tapped through mitigation projects.

It also should be considered that CSA practices for rice do not represent a significant source of GHG reduction or carbon sink in this case. However, in other experiences for irrigated rice, practices such as Alternate Wetting and Drying (AWD) have a great potential to reduce 25-70% methane (CH_4) and nitrous oxide (N_2O) emissions (Chirinda et al., 2018).

Barriers and opportunities: The amount of identified opportunities (35–38) was higher than the barriers (24–25) in both portfolios. However, the qualitative evaluation indicates that the barriers have a higher level of difficulty to be overcome than the opportunities to be seized. This suggests that, despite recognizing a greater number of opportunities, a greater level of effort may be required to ensure that the opportunities enable the necessary conditions for CSA practices adoption. In most cases, the opportunities proposed by the participants are multidimensional, involving mainly education/information and policies/institutions, and to a lesser degree socio-cultural, economic, and environmental. In the case of Region 9, cassava was the only crop with a negative B&O score (S). On the one hand, because it is not a custom to grow this species in a formal/commercial cultivation system and there is also room for sustainable practices and technologies to be implemented in traditional farms where cassava is not grown or is only part of the cultivated species. On the other hand, there is accumulated expertise by farmers and communities on climate-smart practices around crop management. This is an opportunity that should be coupled with efforts to promote communication, and education tools and strategies – such as Farmer Field Schools and/or training sessions with extension officers, NGOs, and government institutions – may facilitate the possibility to increase technical skills and overcome most of the recognized barriers.

Total account: From the different criteria evaluated, Portfolio B had a better performance gathering 7/13 indicators across indicators mainly from the economic point of view. The second criterion of priority was the barriers and opportunities analysis but, in this case, the results show a pattern where there are no great differences between Portfolios A and B. Nevertheless, having in mind that CSA pillars are of high interest for stakeholders (50% weight) and Portfolio A meets 2/3 of the CSA components, then Portfolio A is still being a suitable option that responds to participants expectations and is in line with the goals set by the working group.

Envisioning an action plan for CSA investment portfolios

The last exercise carried out during regional workshops involved the creation of an action plan to implement CSA investment portfolios, outlining in a simple manner the key questions and elements required to move forward in the process of scaling up the adoption of CSA practices and technologies under designed investment portfolios by region. To that end, participants developed a matrix that helped to respond, connect and visualize essential questions such as *What actions and resources are required? Who are the key actors to be engaged?* And *When in the short to long term?* See the following figures. Additionally, the Key Actors were classified by a color code according to the type of support they are able to provide, i.e. Financial and no-financial incentives **(red)**; Support on policy making and programs **(yellow)**; Information and knowledge sharing **(blue)**; Innovation and technology development **(green)**.

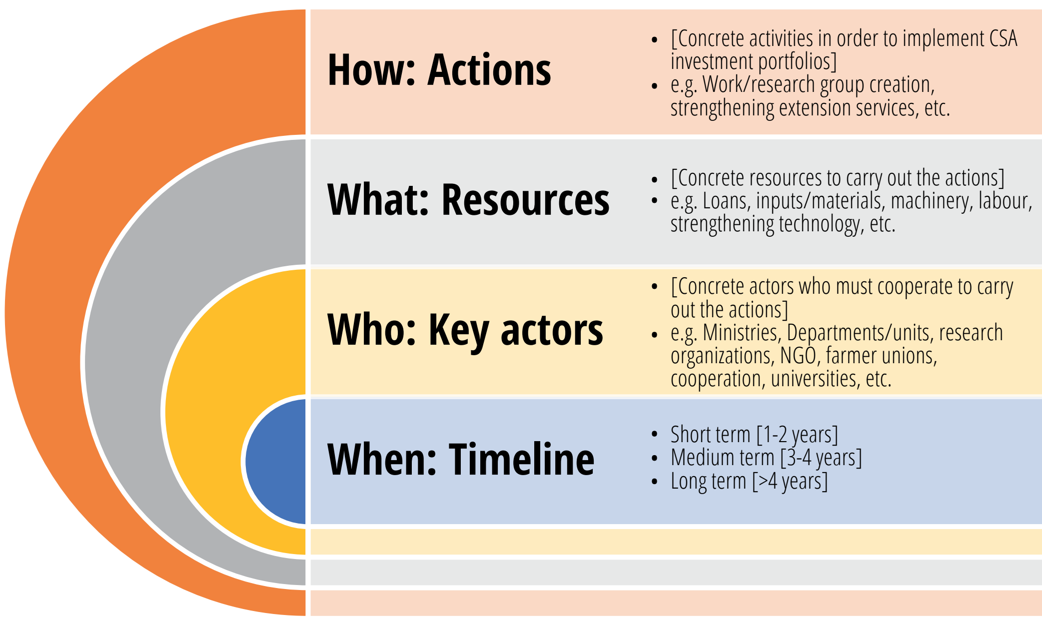


Figure 22. Essential questions and information for setting up an action plan for CSA portfolios implementation.

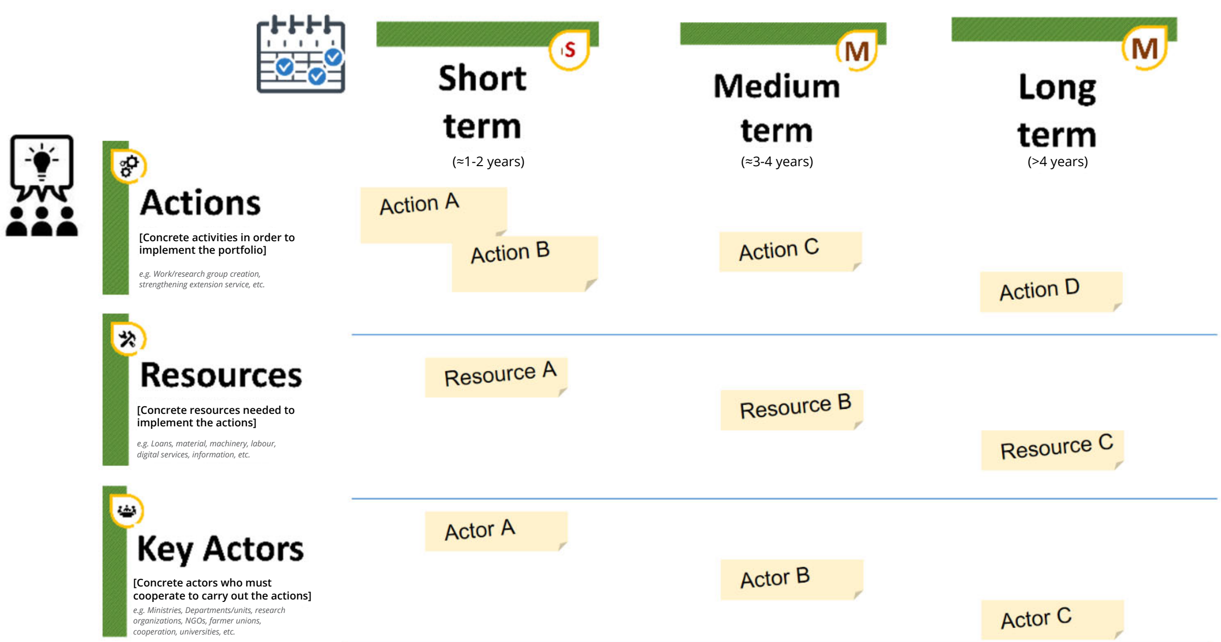


Figure 23. Action plan diagram for CSA portfolios implementation.

Action plan in Region 3

	Short term (≈1-2 years)	Medium term (≈3-4 years)	Long term (>4 years)
Actions [Concrete activities in order to implement the portfolio] *e.g. Work/research group creation, strengthening extension service, etc.*	✓ Identification of key stakeholders. ✓ Creation of steering committees. ✓ Strengthening technical services for capacity building i.e. guide and execute training workshops, Farmer Field Schools, etc. in areas such as IPM, IWRM, clean seeds production, etc. ✓ Generation and sharing of quality data for agricultural purposes e.g. climate, soil, water, crops etc. ✓ Maintenance, and Monitoring and Evaluation activities (M&E).	✓ Identification of additional funding sources. ✓ Maintenance, and Monitoring and Evaluation activities (M&E). ✓ Desilting, excavation, revetment, Weeding. ✓ Set institutional arrangements e.g. around IWRM in MoA. ✓ Establishment of public and private plant nurseries and demonstration plots.	✓ Maintenance, and Monitoring and Evaluation activities (M&E). ✓ Policy reform.
Resources [Concrete resources needed to implement the actions] *e.g. Loans, material, machinery, labour, digital services, information, etc.*	✓ Operational and maintenance facilities and materials e.g. fuel, time, information, machinery (bulldozers, excavators etc.), and telecommunication equipment for remote areas. ✓ Specific input materials for the practices. ✓ Technical personnel and HH.RR. Staff i.e. Scientists and researchers, extension officers, farmer leaders, rangers, water users, among others. ✓ Access to information and technology (I.T.) e.g. Drones, GIS maps, Google Earth images, Climate and Land Use, and Land Use Change databases (international and from the MoA Agencies), APPs, etc. ✓ Service and input material.	✓ Operational and maintenance facilities and materials e.g. fuel, time, information, machinery (bulldozers, excavators, etc.), and telecommunication equipment for remote areas. ✓ Technical personnel. ✓ Planting material e.g. coconut.	✓ Operational and maintenance facilities and materials e.g. Equipment machinery. ✓ Technical and professional personnel.
Key Actors [Concrete actors who must cooperate to carry out the actions] *e.g. Ministries, Departments/units, research organizations, NGOs, farmer unions, cooperation, universities, etc.*	NAREI 🟢🟡🔴🔵 - Ministry of Agriculture (ASDM) 🟡🔴🔵 - IICA 🟡🔴🔵 - Hydromet 🟢🟡🔵 - GRDB 🟢🟡🔵 - OCC (Office of Climate Change) 🟢🔵 - CARDI 🟢🔵 - Guyana Sugar Corporation 🟢🔵 - University of Guyana 🟢🔵 - National Drainage and Irrigation Authority 🟡🔵 - Ministry of Legal Affairs 🟡🔵 - Ministry of communities [NDC, RDC] 🟡🔵 - Environmental Protection Agency 🟡🔵 - Farmers and Farmers groups 🟡🔵 Pesticides and Toxic Chemicals Control Board (PTCCB) 🔴🔵 - Financial Banks 🔴 - Rice producers association 🔵 - Water users associations 🔵 - Guyana Lands and Survey Commission 🔵 - CDC (Civil Defence Commission) 🔵	Food and Agriculture Organization of the United Nations (FAO) 🔴🔵 – Funding Partners 🔴🔵 – IDB (Inter-American Development Bank) 🔴 – Caribbean Development Bank (CDB) 🔴 – NGOs (EXIM) 🔴 – Ministry of Finance 🔴 – CDC 🔵	IDB 🔴 – CDC 🔵 – CDB 🔵

Type of support: Innovation and technology development 🟢; Support on policies formulation and programs 🟡; Financial and no-financial incentives 🔴; Information and knowledge sharing 🔵

Action plan in Region 9

	Short term (≈1-2 years)	**Medium term** (≈3-4 years)	**Long term** (>4 years)
Actions [Concrete activities in order to implement the portfolio] *e.g. Work/research group creation, strengthening extension service, etc.*	✓ Market research on different crops and by-products development. ✓ Knowledge exchange (Farmers exchange, Field Trips, Farmers training, Training of trainers (at Sub-district level).	✓ Strengthening Crop rotation options by sourcing seed banks for different crops. ✓ Strengthening farmers' cooperation and association though creation of Farmers Groups. ✓ Determine Drainage and harvesting areas. ✓ Construction of water harvesting structures. ✓ Environmental impact studies.	✓ Develop policies on water harvesting and drainage systems. ✓ Partnerships and collaboration with central government agencies.
Resources [Concrete resources needed to implement the actions] *e.g. Loans, material, machinery, labour, digital services, information, etc.*	✓ Resource personnel. ✓ Officers and Research staff. ✓ Soil testing kits and soil labs. ✓ Demo plots leaded by farmers and facilitated by extension officers. ✓ Planting material / Public and community nurseries. ✓ Communication material (including digital information) and facilities (e.g. Projectors). ✓ Financing (Grants, budgetary allocation, and loans from banks).	✓ Resource personnel / specialists. ✓ Plan of Action for Regional Development. ✓ Village plans (Agricultural sector). ✓ Information systems. ✓ Topographic surveys. ✓ Equipment and heavy-duty machinery.	✓ Operational and maintenance facilities and materials e.g. Equipment machinery. ✓ Technical and professional personnel. ✓ Assessment and amendment if applicable of Policies and Programmes.
Key Actors [Concrete actors who must cooperate to carry out the actions] *e.g. Ministries, Departments/units, research organizations, NGOs, former unions, cooperation, universities, etc.*	NAREI ●●●● - UNDP ●●●● - Ministry of Tourism, Industry and Commerce ●●●● - Food and Agriculture Organization of the United Nations (FAO) ●●●● - Ministry of Amerindian Affairs (MoIPA) ●●● - IICA ●●● - WWF ●●● - Hydromet ●●● - The New Guyana Marketing Corporation (NGMC) ●●● - GRDB ●●● - CIAT ●●● - Conservation International ●●● - CARDI ●● - University of Guyana ●● - Guyana School of Agriculture ●● - Regional Democratic Councils ●● - Santa Fe Farm ●● - National Drainage and Irrigation Authority ●● - Kanuku Mountains Community Representative Group (KMCRG) ●● - Financial Banks ● - South Central People's Development Organisation (SCPDA) ● - South Rupununi District Council (SRDC) ● - North Rupununi District Development Board ● - Guyana Lands and Surveys Commission ● Local NGOs ●	Rupununi Livestock Producers Association (RLPA) ●● - Environmental Protection Agency, Guyana (EPA) ●● - Brazilian Agricultural Research Corporation (EMBRAPA) ●● - Rupununi Chambers and Commerce and Industry (RCCI) ●	Ministry of Agriculture ●●● – Local farmers ●● – Village councils ● – Financial Institutions (Banks etc.) ●

Type of support: Innovation and technology development ●; Support on policies formulation and programs ●; Financial and no-financial incentives ●; Information and knowledge sharing ●

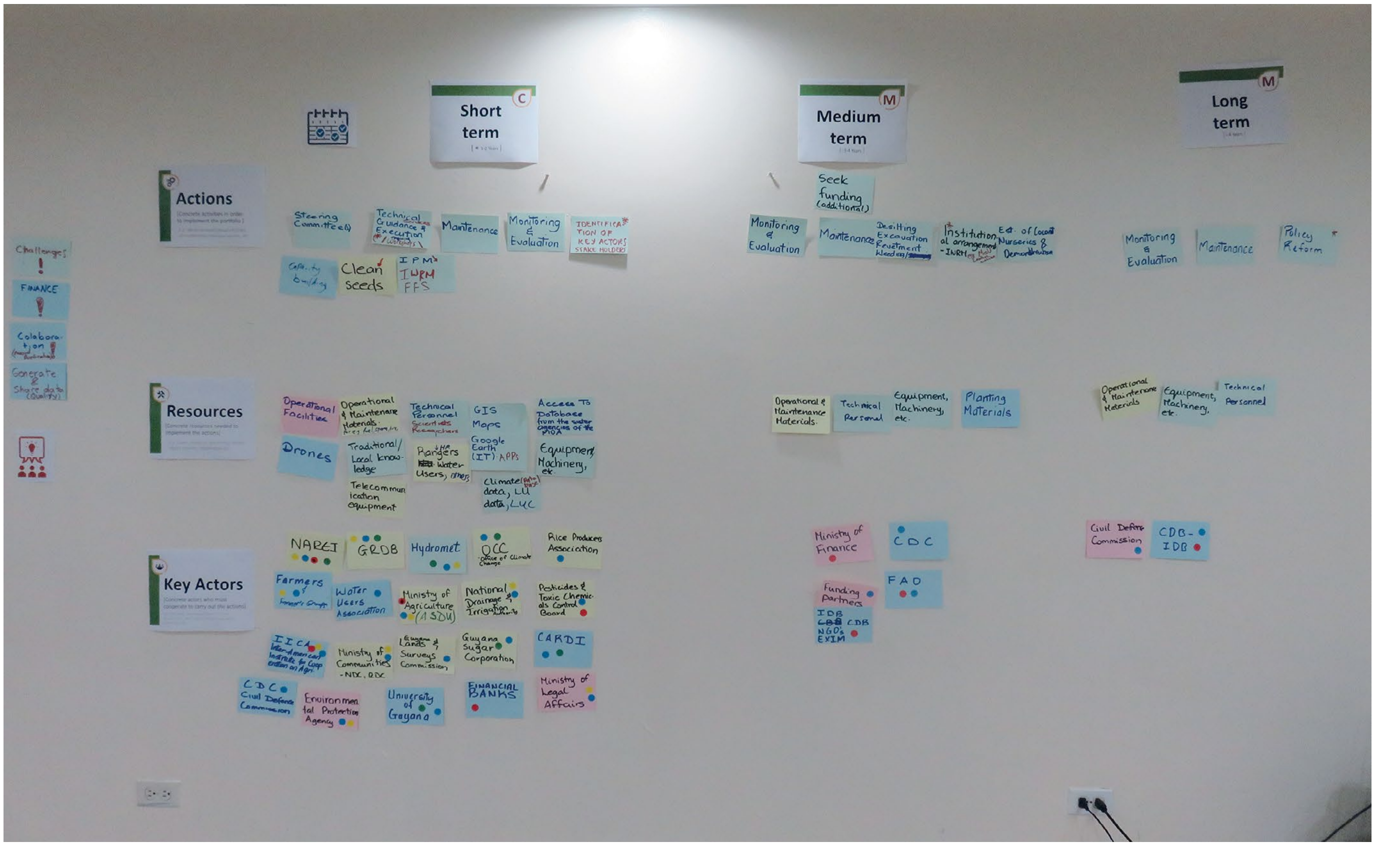


Figure 24. Action plan activity in Region 3 (top) and Region 9 (bottom).

Policy considerations

The CSA prioritization process contributes to revealing emerging tradeoffs and synergies to be addressed in order to inform context-specific decisions, maximizing the information and resources available. This requires a critic and systematic analysis of value networks to explore, from multiple perspectives, the socio-economic and environmental feasibility of implementing CSA portfolios rather than isolated solutions. Therefore, building on internal and external opportunities and barriers that farmers face in the regions is determinant to influence the conditions for successful scaling-up of CSA actions. Notwithstanding the high level of uncertainty and variability of these conditions, Guyanese farmers, public officials and sectorial stakeholders are invited to play an active role as agents of change, facilitating the connections and actions needed to overcome current and potential climatic challenges and their related impacts, harmonizing efforts in the transition to a sustainable food system in the country.

- Most of the prioritised and evaluated CSA practices are financially attractive options for generating greater environmental and economic value in small-scale farms, compared to conventional farming systems – business as usual (BAU). However, the CSA practices that under the assumptions of the analysis turn out to be not financially viable are likely to be profitable options when education and information tailored to the agricultural sector is aligned with the local needs and public policies. This contributes to materializing the required changes in market conditions, through key actions such as maximizing product price for farmers by creating shorter and local marketing circuits, keeping production costs in stable and fair proportions, making affordable interest rates in agricultural loans, regulation of agricultural imports, particularly products that local producers cannot compete with, etc.
- Environmental externalities generated by CSA practices related to on-farm diversification, conservation of natural ecosystems, and climate change mitigation (carbon capture or GHG emissions reduction) have the potential to improve the economic conditions of farmers, and should be further developed as part of medium- to long-term livelihood diversification strategies. Especially considering the natural treasure that the country has in terms of forests and water resources. Therefore, it is vital that agricultural stakeholders put effort in strategically organizing themselves to boost projects that strengthen research and knowledge generation, that sustain sound projects for creating economic opportunities such as value-added products, payment for environmental services (PES), agro-tourism, ecotourism, community forest management (CFM) under agroecological approaches led by and for indigenous and farmer communities.
- Under a changing climate perspective, CSA practices related to water management are a priority in both regions. Even though they are profitable options, these imply relatively high costs for the farmer, which lengthen the payback period of the investments. This situation should be managed in parallel fostering education on livelihood diversification strategies, coupled with permanent state support, through facilitating the provision and/or availability of particular services such as heavy-duty machinery, public seed banks with local varieties adapted to extreme climate conditions, and tolerance to pests and diseases, adequate road systems, digital communication platforms and marketing facilities, etc., at the community and regional levels.
- Another relevant role of the State, as well as farmers associations and grassroots organizations in each region, is the strengthening and continuous updating in agricultural education and extensions models that effectively tackle barriers related to crop diversification and sustainable management strategies. Generation of local agricultural inputs is only one example of business opportunity that contributes to reducing as much as possible the reliance on external – and generally expensive – inputs such as synthetic pesticides and fertilizers that often represent the most expensive items in the cost structures of farmers. Moreover, it alleviates potential negative implications for both human and environmental health due to contamination of soil and water bodies, and reduction of carbon footprints.
- In both study regions, there is a good understanding of relevant stakeholders and the type of support they may offer to achieve key activities to make CSA portfolios useful instruments – concrete enough but flexible at the same time – to guide investments in the agricultural sector focused on small-scale farmers. However, it is still important to work towards achieving harmonious coordination and commitment of public and private initiatives, since diverse projects, programmes, and plans often present tight and divergent timelines, minimizing the possibilities to avoid duplication of efforts.
- Since there are no blanket solutions that respond in a generic way to context-specific agricultural dynamics and realities, it is important to expand this type

of analysis to other regions in Guyana, looking for systematic methods to prioritize CSA practices and technologies as part of a broader stakeholder-driven process for developing deeper analyses of best-bet CSA actions in the territory.

- Complementary methodologies, as the CSA Country profiles or the Climate Risk County Profiles, should be explored to strengthen regional and national planning as valuable inputs for an informed decision making process.

Figure 25 Workshop 2 participants day 2, in Region 3 (top) and Region 9 (bottom).

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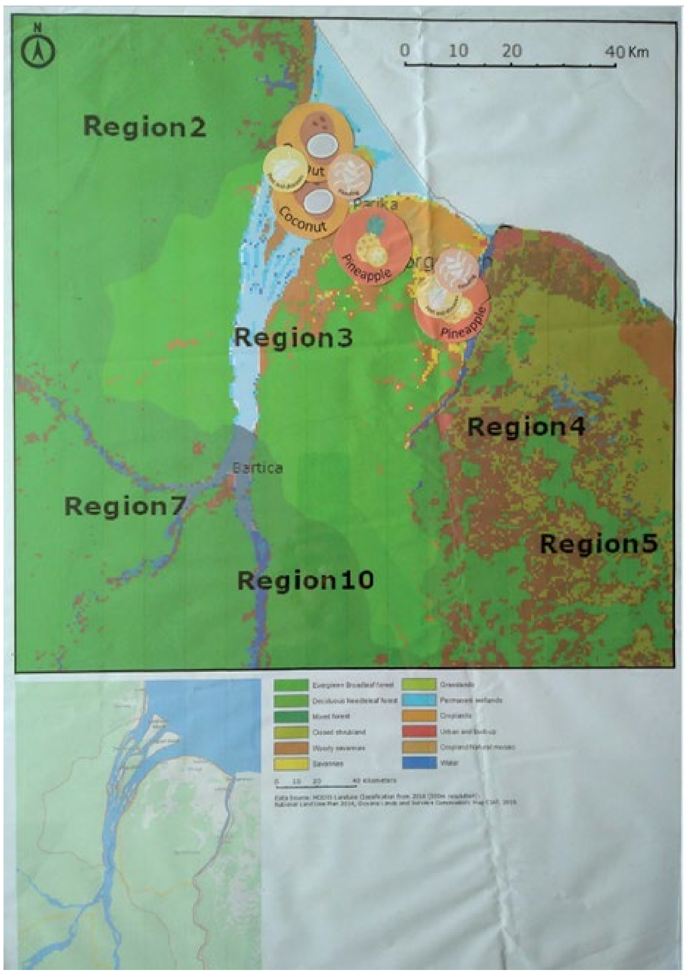
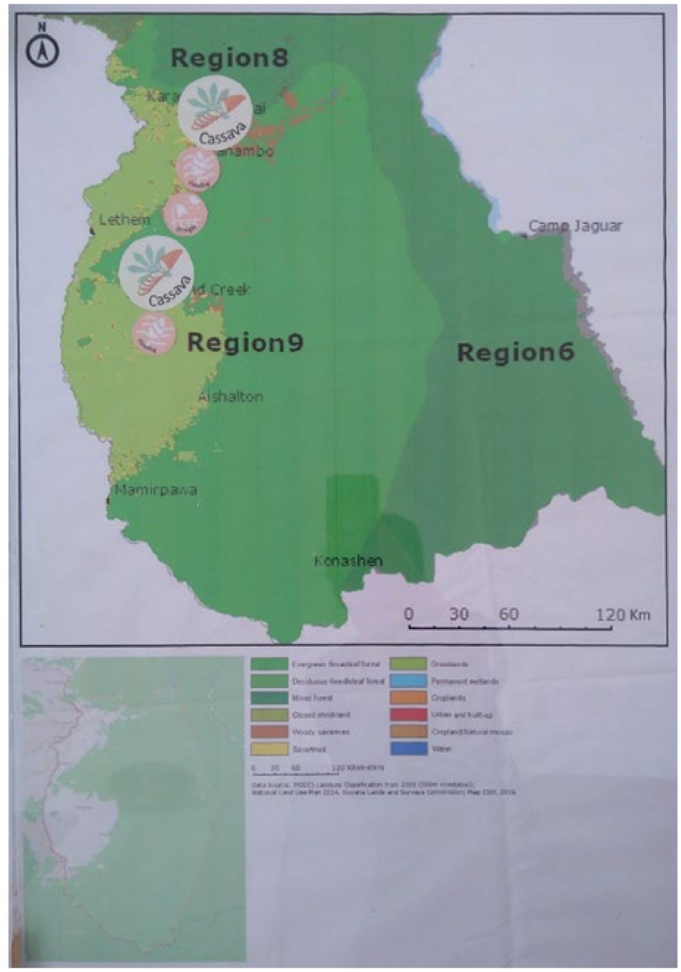
Annexes

1. Location of production systems and climatic risks in Regions 3 and 9





2. Long list of CSA practices across the value chain and by production system in Guyana

Stages considered along the Value Chain (VC):

(i) Input supply → (ii) On-farm production → (iii) Post-harvest, processing and storage → (iv) Transport and Marketing

CASSAVA	CSA practice / technology	Category
i	Community seed bank (provide planting material)	Seed /variety improvement
ii	Improved land drainage systems / ridging	Water management
ii	Water efficient irrigation (e.g. Spray irrigation)	Water management
ii	Field sanitation (remove infected crop residues)	IPM
ii	Crop rotation (with vegetables)	IPM
ii	Colour traps for monitoring or mating disruption	IPM
ii	Agroforestry systems (e.g. alley cropping leguminous trees and or/ shrubs)	Multi-strata agroforestry
ii	Biological control-natural enemies (e.g. predators such as ladybirds, parasitoids and parasites)	Biocontrol of vectors
ii	Use of climate-resilient varieties (resistant to drought, flood and salinity)	Tolerance to stress
iii	Use of hand lifter / careful hand harvesting cutting main stem	Harvesting techniques
iii	Cleaning and washing (e.g. use of cotton gloves/soft brush)	Improved processing
iii	Small-scale equipment for cassava flour, chips or grated cassava production	Improved processing
iii	Low-cost storage structures (e.g. above-ground clamp silos)	Improved storage
iv	Use of durable craters for harvesting and transport	Improved storage

COCONUT	CSA practice / technology	Category
i	Use of climate-resilient varieties (resistant to drought, flood and salinity)	Seed /variety improvement
i	Coconut varieties diversification	Seed /variety improvement
ii	Improved land drainage systems	Water management
ii	On-farm nursery	Crop management
ii	IPM (e.g. economic thresholds; monitoring insects population or disease signs)	IPM
ii	Integrated pest management (e.g. insect traps)	IPM
ii	Agroforestry systems (e.g. shade trees, intercropping with cocoa)	Multi-strata agroforestry

RICE	CSA practice / technology	Category
i	Use/produce clean seeds	Seed /variety improvement
i	Use of climate-resilient varieties (resistant to drought, flood and salinity)	Seed /variety improvement
ii	Improved land drainage systems (programs to dredge canals and knowledge sharing)	Water management
ii	Alternate Wetting and Drying system (AWD)	Water management
ii	Use of disease-resistant varieties (e.g. BR and G98 varieties for blast disease)	IPM
ii	IPM (e.g. field sanitation removal and destruction of infected crop residue)	IPM
ii	Avoid over fertilization specially with Nitrogen-based synthetic fertilizers	INM
ii	Crop residues/straw incorporation after harvesting	INM
iii	Ensure clean and free of pest storage conditions	Improved storage

PINEAPPLE	CSA practice / technology	Category
i	Nursery (production of disease-free planting material)	Seed /variety improvement
i	Use of climate-resilient varieties (resistant to drought, flood and salinity)	Seed /variety improvement
ii	IPM (e.g. Field sanitation removal and destruction of infected plants/crop residue)	IMP
ii	Water efficient irrigation systems (e.g.: drip)	Water management
ii	Improved land drainage systems / ridging	Water management
ii	Artificial flower-induction	Integr. Crop Management
ii	Planting distance (Double row)	Integr. Crop Management
ii	Mulching (e.g. coconut fiber, pineapple leaves)	ISFM
ii	Agroforestry systems (e.g. intercropping with pumpkin or melons, alley cropping)	Multi-strata agroforestry
iii	Planting material storing (anti-insects solutions)	Improved Storage
iv	Wood/plastic boxes for transport and storage	Improved Storage
iv	Grading and packaging (For export: Fiberboard cartons/no-plastic)	Harvesting techniques

PLANTAIN	CSA practice / technology	Category
i	Bunch covers (non-plastic/organic material)	Organic inputs
i	Use of climate-resilient varieties (resistant to drought, flood and salinity)	Seed /variety improvement
ii	Improved land drainage systems	Water management
ii	Agroforestry systems (e.g. intercropping and/or alley cropping with *see list)	Multi-strata agroforestry
ii	Composting crop/farm residues	INM
ii	Field sanitation (Remove infected crop residues)	IPM
ii	Crop rotation (e.g. yams, sweet potato and eddoes)	Crop rotation
ii	Use of crop maturity standards (measuring fruit diameter with calipers, or monitoring days after bunch shooting)	Harvesting techniques
iii	Use of stackable field containers	Improved Storage
iii	Covered collection points	Improved Storage
iii	Use of foam padding during transport	Improved Storage
iii	Use strong-well ventilated cartoon containers	Improved Storage

SWEET POTATOES	CSA practice / technology	Category
i	Production/use of clean planting material	Seed /variety improvement
i	Use of climate-resilient varieties (resistant to drought, flood and salinity)	Seed /variety improvement
i	Use of disease-resistant varieties	Seed /variety improvement
ii	Improved land drainage systems	Water management
ii	Agroforestry systems (e.g. intercropping with *see list)	Multi-strata agroforestry
ii	Biological control- companion planting (e.g. marigold flowers, tulsi, neem)	IPM
ii	Crop rotation	Crop rotation
ii	Grading by size and quality	Harvesting techniques
ii	Covered field containers (e.g. smooth wood or rigid materials)	Improved storage

*Species for agroforestry systems: preferably nitrogen-fixing; deep root systems to minimize competition with the crops; good leaf litter production for mulch production:

- *Acacia mangium*
- *Erithrina poepigiana*
- *Gliricidia sepium*
- *Leucanena leucocephala*
- *Neem, azadirachta indica*
- *Trysil, Pentaclethra macroloba*
- *Whikie, Inga rubignosa*

VC	Others ON-FARM	Category
ii	Bio-degradable/organic packaging materials	Organic inputs
ii	Organic fertilizers (e.g. Rhizobium inoculation)	Organic inputs
ii	Organic-allowed pest/disease substances (e.g. Copper based fungicides etc.)	Organic inputs
ii	Improved land drainage systems / diversion ditches	Water management
ii	Rain water collection/conservation structures (e.g. wells)	Water management
ii	Shade houses / greenhouses	Protected agriculture
ii	Agroforestry systems (Intercropping, improved fallows, alley cropping, living fences/barriers, wind break/shelterbelts, shade trees)	Multi-strata agroforestry
ii	Aquaculture ponds	Aquasilviculture
ii	Agrosilvopastoral systems	Silvopastures
ii	IPM (e.g. keep areas of natural habitat; insect traps color/pheromones; biological controllers; plant extracts such us neem or marigold)	IPM
ii	IPM (e.g. field sanitation removal and destruction of infected crop residue)	IPM
ii	Green manures/cover crops	ISFM
ii	Grass strips	ISFM
ii	Reduced / No-tillage	Reduced / No-tillage
ii	Crop rotation	Crop rotation

VC	Others OFF-FARM / Programmatic	Category
	Farmer field schools	Educ. & Capac. Building
	Farmers and Water Users Associations	Educ. & Capac. Building
	Education and capacity building for farmers and extensionists (e.g. Farmers Field Schools, and/or ICT tools [GeoFarmer, PICSA]	Educ. & Capac. Building
	Land restoration / agro-ecosystems conservation (e.g. planting mangrooves, planting trees)	Climate services
	Establish contract/ special arrangements between farmers and buyers	Climate services
	Local agroclimatic advisory services	Climate services
	Coordinated planting schedule	Climate services
	Market information platforms (web-based / ICT)	Climate services
	Agricultural insurance	Climate services
	Community seed banks (Local production of planting material with quality standard)	Seed /variety improvement
	Use of climate-resilient varieties (resistant to drought, flood and salinity)	Seed /variety improvement
	Improved land drainage systems	Water management

3. CBA indicators definition

Area and timeframe

In order to simplify the analysis and interpretation process, the data is standardized to one acre – the most common area measure in Guyana. For each crop, the natural cycle (i.e. productive life cycle) was considered; however, it is assumed that crops are grown year after year – in the case of annual crops – and/or maintained – in the case of perennial crops – until completing a 10 years period. This is adjusted to equate cash flows of the analyzed crops with those with the longest productive cycle, the above, to be able to compare all cash flows within a similar time frame. Thus, all CBA indicators (NPV, IRR, etc.) are calculated for a period of 10 years. For example, the cassava cycle is less than one year; however, for standardization, it is assumed that the farmer plants cassava for 10 years.

Net Present Value (NPV)

The most widely used efficiency evaluation criterion is the net present value (NVP). In any context, for a project to be acceptable, the NPV must be equal to or greater than 0, which means that the benefits exceed the costs once the effect of time and discount rate are considered and as shown in the following equation:

$$NPV_r = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} = \sum_{t=0}^{n} \frac{(I_t + SA) - (CI_t + CMC_t)}{(1+r)^t}$$

Where: (*r*) is the annual discount rate; (*t*) is the number of periods (years) from the beginning of the investment; (*n*) is the time horizon of the analysis; (*B*) are the benefits; (*I*) corresponds to income; (*SA*) socio-environmental services [only integrated in the case of externalities assessment]; and (*C*) the costs [including investments and maintenance].

Internal Rate of Return (IRR)

The IRR stands for the discount rate that equates to the present value of the flow of future net benefits to zero, measuring the profitability of each practice in relation to the initial investment. An investment is considered profitable if its IRR is higher than the cost (e.g. the discount rate) (Ng'ang'a et al., 2017):

$$\sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} = 0 \; if \; the \; IRR > r; NPV > 0$$

Cost-benefit Ratio (C/B)

C/B is a ratio that indicates the relationship between the relative monetary costs and benefits of the CSA practice. If the ration is greater than 1.0, the project is expected to deliver a positive NPV. On the other hand, if the value is less than 1.0, practices' costs outweigh the benefits, therefore, the project is not desirable.

Payback Period (PP)

This indicator refers to the amount of time (years) it takes to recover the costs associated to the CSA practice investment. Shorter payback period means a more attractive investment, while longer PP is less desirable. This PP is calculated by dividing the amount of the investment by the annual cash flow, and must be put in context considering the crop production cycle (annual crops, perennial, semi-perennial), providing an expectation of when the investment will pay off.

Discount rate (DR)

It is not an indicator per se. By definition discount rate (DR) is the interest rate used in the analysis to determine the present value of future cash flows from an investment. This rate is used in a CBA as an approximation of the social cost of opportunity for the money. The main purpose is to account for the loss of economic efficiency of the investment due to internal or external risks (Saín et al., 2017).

Crops and CSA practices

A total of 20 practices were evaluated for both regions based on the top two practices from the long list. Particular assumptions for each case are presented in Table 11 below:

Table 11. Crops, CSA practices, and assumptions in Region 3 and Region 9.

Region	Crop	Crop cycle (months)	CSA Practice	Practice lifecycle (years)	Yield response time (years)	Additional assumptions
3	Cassava	6 to 7	Improved drainage system	3	0.75	–
			Water efficient irrigation-sprinkler irrigation	3	0.75	
	Coconut	≥ 120	Improved drainage system	3	1	Crop harvest starts from year 3. An additional income from selling coconut water is considered.
			Diversification of varieties: Tall + Dwarf	-	5	Crop harvest starts from year 3. A portion equivalent to 10% of the cropped area with older crops is considered. An additional income from selling coconut water is considered.
	Pineapple	14 to 16	Water reservoir and irrigation + pump	5	1.5	Crop harvest starts from year 2. A potential average yield increase by 40% is assumed under suitable agronomic management conditions.
			Use of climate-resilient varieties	-	1.5	
	Plantain	12 to 15	Improved drainage system	1	2	-
			Improved irrigation system - Sprinkler irrigation	1	1	
	Rice	4 to 4.5	Production and use of clean seeds	5	0.5	The life cycle of the practice corresponds to the cycle of cultivation.
			Integrated Pest Management-Monitoring	-	1.5	
	Sweet potato	3 to 3.5	Improved drainage system	3	0.3	-
			Use of climate-resilient varieties	-	-	The life cycle of the practice corresponds to the cycle of cultivation. Mon Repos and Parika varieties are considered.
9	Cassava	6 to 7	Crop rotation	4	1	It is assumed bean rotation is carried out in an equal proportion of cultivated land. Yield and price for the secondary crop are 55 kg/ha (44 lbs/Acre), and 600 GYD/lbs, respectively.
			Improved drainage system	10	1	-
	Peanuts	4.5 to 5.3	Crop rotation with red beans	3	1	It is assumed that bean rotation is carried out in an equal proportion of cultivated land. Yield and price for the secondary crop are 55 kg/ha (44 lbs/Acre) and 600 GYD/lbs, respectively.
			Conservation of natural areas	-	-	It is assumed that rotations are made on small patches of land within the farm, allowing the rest of previously cultivated areas (fallow period).
	Plantain	12 to 15	Intercropping	2	0.5	It is assumed that bean intercropping is carried out in the same proportion of cultivated land. Yield and price for the secondary crop are 55 kg/ha (44 lbs/Acre), and 600 GYD/lbs, respectively.
			Improved drainage system	10	2	-
	Rice	4 to 4.5	Improved drainage system	-	-	The yields for this crop were adjusted according to the values reported in Region 3, considering agroecological and crop management differences.
			Time of planting	-	-	The yields for this crop were adjusted according to the values reported in Region 3, considering agroecological and crop management differences.

	#	CSA INDICATORS
	#	**By IMPLEM** ENTING the CSA practice what are the expected changes in the following indicators?
FOOD SEC	1	**YIELDS** By implementing the CSA practice, what are the expected changes in crop/livestock yields per season on 1 hectare? (kg/ha)
	2	**POST-HARVEST LOSS** By implementing the CSA practice, what are the expected reductions in (pre- and post-harvest) losses of crops and livestock? Every season on 1 hectare? (kg/ha)
	3	**INCOME** By implementing the CSA practice, what are the expected changes in income and/or profits per unit of area? (S/ha/season or year)
ADAPTATION	4	**WATER AVAILABILITY** By implementing the CSA practice, what are the expected changes in the availability of water for crops and livestock (both surface water, aquifers, and in the soil) per season? (m^3 season)
	5	**WATER USE EFFICIENCY** By implementing the CSA practice, what are the expected changes in the efficiency with which water is used? Scale: -10 = less efficiency / +10 - greater efficiency. Refers to water used for crop irrigation and/or livestock production. (liters/kg of product/season)
	6	**SOIL DISTURBANCE** By implementing the CSA practice, what are the expected changes in the health of soils (organic matter content, soil structure, nutrient content, soil depth, and/or water holding capacity)? scale: -10= highly disturbed / +10= no disturbance or zero-till) (no specific metric)
	7	**CLIMATE RISKS MANAGEMENT AND PREVENTION** By implementing the CSA practice, what are the expected changes in farmers' capacity to manage, avoid and/or withstand climate risks and hazards (e.g. drought, floods, and dry spells) related to the value chain?
	8	**DIVERSIFICATION OF INCOME SOURCES** By implementing the CSA practice, what are the expected changes in the level of diversification of farmers' agricultural activities on a crop/livestock farm? (number of agricultural/economic activities on the farm)
MITIGATION	9	**ENERGY USE (FOSSIL FUELS)** By implementing the CSA practice, what are the expected changes in the *efficiency* of use of fossil fuel energy in the value chain? Scale: -10= reduced efficiency / +10= increased efficiency seasonally
	10	**BIOMASS (ABOVE-GROUND)** By implementing the CSA practice, what are the expected changes in the availability of above-ground biomass (trees, shrubs, grasses and other vegetation) within the production system? Above-ground biomass (AGB): All living biomass above the soil such as trees, crops, grasses, tree litter, seeds. Example: a forest can accumulate more AGB than a desert. (ton/season/ha)
	11	**BIOMASS (BELOW-GROUND)** By implementing the CSA practice, what are the expected changes in the availability of below-ground biomass and soil organic matter in the production system? Below-ground biomass (BGB): All living biomass of live roots. Fine roots <2 mm diameter are often excluded. Example: a forest can accumulate more BGB than savannah or desert. (ton/season/ha)
	12	**SOIL CARBON STOCK** By implementing the CSA practice, what are the expected changes in the quantity of organic matter accumulated in soil in areas under crop/livestock? (% OR kg/ha OR kg/m^3)
	13	**METHANE EMISSIONS** **In the case of livestock** By implementing the CSA practice, what are the expected changes in the quality of animal diet (including diet diversification, forage quality, digestibility) per season, on a livestock system? Scale: -10= reduced quality /+10= increased quality **In the case of rice** By implementing the CSA practice, what are the expected changes in the amount of methane released into atmosphere per season, on a rice system? Metric: N/A
	14	**NUTRIENT USE EFFICIENCY** By implementing the CSA practice, what are the expected changes in the amount of Macro and Micro nutrients available for plants in the soil?
	15	**GENDER SMARTNESS (FOCUSING ON WOMEN)** By implementing the CSA practice, what is the expected reduction in labour, time spent in the field and distance traveled by women for agriculture-related activities? Scale: -10= huge increase in labour / +10= huge reduction in labour

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